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Hardy, E. A.
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Henry, T. Cradock
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Rix, R. E.

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Lynch, Miss E.

London, W.13
Shotts, A.

London, W.14
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Derby
  McKane, N. B.

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  Shapland, A. F. D.
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  French, J. H.
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  Fanner, M. H.
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  Vaus, K.

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  Munday, M. J.
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  Morse, P. H.
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  Marx, R.
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  Rumble, J. F. S.
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  Thorn, N. K.
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  Wreakes, G.
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  Noar, G. A.
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Sarll, D. W.
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Wigan
Langford, L. F.

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Leicester
Chamberlain, G. H.
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Smith, T.

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Scunthorpe
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Dimock, J. R.
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Hayes
Swift, P. A.
Heston
Valentine, H. B.
Hounslow
Mandiwall, H.
Isleworth
Hardy, D. K.
Kenton
Baker, C. D.
Northwood
Hudson, J. A.
Pinner
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Fulstow, E. D.
Ruislip
Rogers, D. A.
St. Margaret's-on-Thames
Lindon, Mrs. E. G.
Staines
Carr, A. S.

Norfolk
Norwich
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Sheringham
Dumbrell, Miss J. M.

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Littlefield, W. H.
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Stockfield upon Tyne
Bennett, D. T.
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Nottingham
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Tredgold, H. V. G.

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Oxford
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Savage, M.

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Shrewsbury
Scott, M. F.

Somerset
Bath
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Poulter, N. M.

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Huddart, A. G.
Lichfield
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Stafford
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Ashtead
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Redhill
Tittle, J. J.
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Howard, R. D.
Surbiton
Frischmann, L.
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Upson, N.
Sutton
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Sussex
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Adam, K. W.
Brighton
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Chichester
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Robertson-Ritchie, Mrs. E. L.
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Dakers, G. H.
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Townend, P. I.

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Chippenham
Swann, A. J.
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Campbell, Miss D. M. Y.
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Hall, J. J.

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Malvern
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Stourbridge
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Yorkshire
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Doncaster
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Hull
Webb, G. H.
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Marsh, W.
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Alexander, S. H.
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Price, A. H. K.
Strensall
Bowen, E. J.

III. Wales

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Colwyn Bay
Duchesne, H. W.
Llandrindod Wells
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Llandudno
Jones, J. E.
Swansea
Parry, H. L.

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McDonald, A. A. M.
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White, Prof. T. C.
Dunblane
Hood, M. R.
Dumfries
Baker, A.
Dundee
Archibald, W. C.
Martin, J. H.
McCartney, T. P. G.
McEwen, J. D.
Munro, D.
Edinburgh
Buchan, A.
Hargreaves, J. A.
Haynes, S.
Hopkin, G. B.
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Elderslie (Johnstone)
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Forfar
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Glasgow
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Cockburn, A.
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Govan, I. G.
Inverness
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Mears, Miss R.
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Stirling
McGonigal, F.

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Belfast
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Bonnar, E. T.
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Richardson, Mrs. M. E.
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O'Connor, P. J.
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Dockrell, R. B.
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Friel, S.
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MacCauley, F. J. L.
Thurles
Connolly-Meagher, T. A.

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Watson, D. C.
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Tsaltas, G. K.

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Choo, T. C.
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Lee Chin Kung
Leong, C. T.
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Manara, G.

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Gilbert, G. H.
Lang, E. T.
Willis, L. E.

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Aamodt, A. C.
Engh, Olav, Jun.
Krogstad, Olav
Selmer-Olsen, R.

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Faisinger, B. E.
MacLeod, D. N.
Oosthuizen, L.

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Brears, O. B. (Ecuador)

Sweden
Ahlgren, J.
Billberg, B.
Granerus, R.
Granse, K. A.
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Gottlieb, A. W.
Grossman, R. C.
Jann, H. W.
Kelsten, L. B.
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Schleimer, M.
Sillman, J. H.

Zambia
Ovington, H. M. J. Y.

FURTHER THOUGHTS ON MONOBLOC THERAPY

R. E. RIX, F.D.S., L.R.C.P., M.R.C.S., D.Orth. R.C.S.

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I AM very aware of the honour you have done me by electing me President again after twenty years. In the intervening period we have had many highly scientific papers upon patterns of skeletal growth and soft-tissue behaviour. We have become familiar with the electromyograph and have learned our profile X-ray geometry. The cream of us can already understand the nomenclature of statistics, and there is probably still time for all but me to learn. This paper is geared to the humble chairside. It presents some thoughts and practices which I have found useful.

Although Andresen monobloc therapy has already been discussed by the Society I think that there are aspects which have still not been covered and I think, too, that its range of usefulness has not been fully exploited. I suspect that since purists can level certain valid criticism against it, its adoption down the ranks is more curtailed than it need be and that some practitioners tend to be discouraged even from trying to understand it. I have the feeling that, if the subject could be aired a little more, practitioners could do more for more patients with Class II, division 1 dentitions with less technical expertise and with more ease to the patient. When I mention less expertise I do not mean less care and precision. I am not going to discuss monoblocs in relation to Class III dentitions. They are really only of use for the so-called postural Class III condition which responds readily to quite simple appliances.

Monobloc therapy is for mass movements and not, of course, for correction of bizarre displacement and rotation of individual teeth. It is generally agreed that it is satisfactory for applying intermaxillary traction to *ample* arches in Class II, division 1 relationship (*Fig.* 1) where the incisor apical relationship is about normal or slightly 'postnormal'. It is successful under these conditions because it is capable of exerting an effective back thrust on the ample upper arch with no crowding in $\underline{87|78}$ regions and because the intermaxillary anchorage for this back thrust does not materially disturb the ample lower arch. When the six lower fronts are capped by the bloc to prevent them from tilting there is, I would say, less unwanted disturbance of the lower arch than used to be seen following plain labiolingual intermaxillary traction apparatus. Also its use

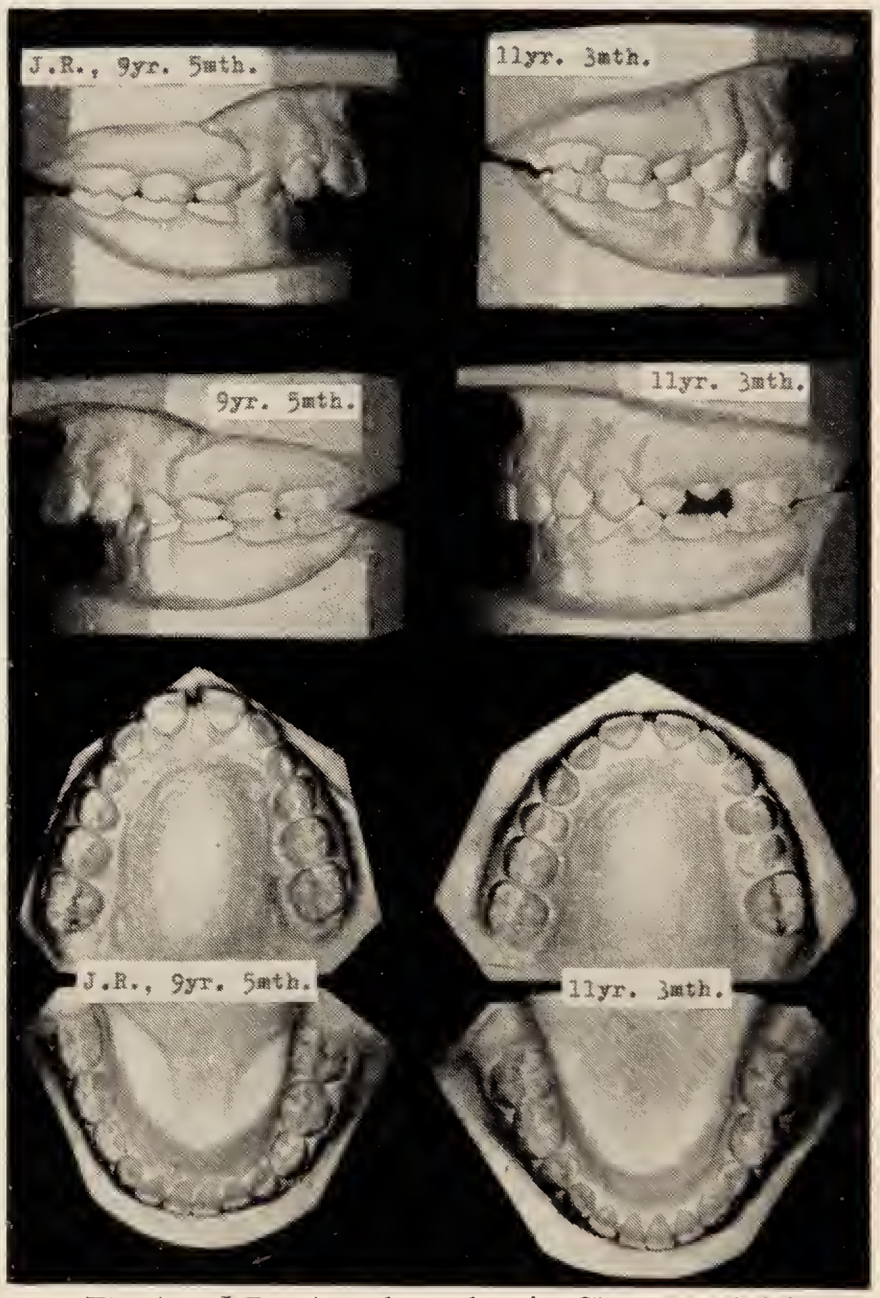

Fig. 1.—J.R. Ample arches in Class II, division 1 relationship likely to respond well to monobloc therapy.

is, I think, accompanied by fewer halting episodes than are met with in the use of upper appliances employing extra-oral anchorage to secure a back thrust on the upper arch.

For many years now I have formed a large half-moon shaped window at the front of the bloc (*Fig.* 2). It avoids the necessity of trimming behind the area of the crowns and roots of the

Presidential Address presented at the meeting held on 10 January, 1966.

upper incisors. Respiration is not embarrassed during the occasional periods of nasal obstruction from colds. Speech is possible with quite reasonable clarity and altogether the bloc is very readily accepted. I have been asked on several occasions by patients whether they can go on using it at night after treatment has finished because it is so comfortable and comforting.

The fear that the window will not hold back a tongue which might be thought to be creating an anterior open bite is groundless. There are two sorts of anterior open bite. The common sort gradually goes whether the bloc is complete in front or contains a window. The less common sort is not susceptible to change with appliances whatever appliance is used. One's background knowledge of skeletal framework and soft-tissue morphology and behaviour helps one to discriminate and to discuss with the parents what can and cannot be done. I do not want to be side-tracked into an abstruse dissertation on these tricky issues. The block has no mystical properties for overcoming unpromising skeletal and soft-tissue conditions. The only practical point is that the common variety of open bite has to be allowed to improve by temporarily doing without the capping of the lower incisors. They are then free to rise occlusally. You can see that during this stage intermaxillary anchorage is about the same in principle as would be obtained from fixed labiolingual appliances, but it is usually a short stage. As soon as the stage passes to what can be labelled an incomplete overbite the bloc can be modified to cap the incisors.

Fig. 2.—Half-moon shaped window. Base line formed by capping over the lower fronts, sides limited by boxed-in canine wires. Left side of bloc untrimmed.

The labial bow is thick, 0·9 or 1·0 mm. diameter, not primarily because it might get bent if the patient lies on it at night, but because any wires on blocs are not conventional thin resilient wires. The patient causes the bloc to tap teeth intermittently into new positions. It is no good hoping that light springs will tap a tooth anywhere. The bow is kept just in contact with the incisors, and sometimes when one wants the upper cheek teeth to be tapped more distally than the incisors need to be tapped back, the bow is kept out of contact with the incisors. The points of exit of the bow must not nestle closely to the contact points of $\underline{43|34}$. They must be below and distal to those contacts.

An important adjunct when treatment is started within about a year of the eruption of the permanent canines or after they have erupted, is a pair of boxed-in palatal wires of 0·7 mm. diameter touching the mesial surface of $\underline{3|3}$ or $\underline{C|C}$ (*Fig.* 2). They insure that the canines receive as efficient a distal thrust as the cheek teeth are receiving. Without these wires a space slowly opens up between upper canines and first premolars (*Fig.* 3). When there is a space at the start of treatment the wires are adjusted just a millimetre at a time to impart a firmer thrust on the canines until they contact the first premolars.

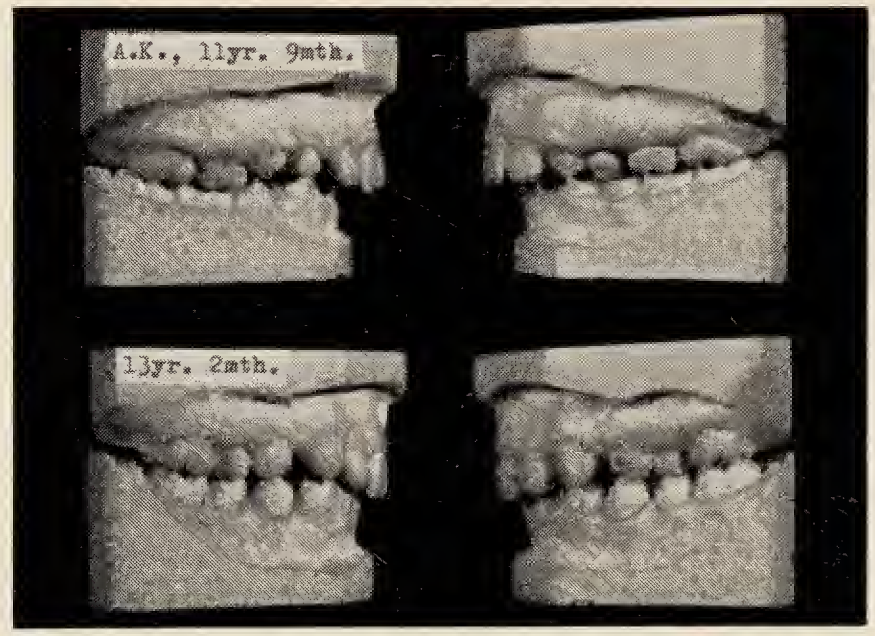

Fig. 3.—A. K. Response to monobloc without canine wires. $\underline{654|456}$ moving distally without commensurate distal movement of $\underline{3|3}$.

Concerning trimming, it needs a practical demonstration rather than a verbal description. I trim in a pretty orthodox way in the upper half, and I make sure that I leave the buffer areas of the bloc reaching as far into the interproximal spaces as the contact points of the cheek teeth will allow. The buffer areas look like a series of deflecting blades. In the lower half on the bloc I trim in an unorthodox way in so far as I trim away from the distal contours of the lower cheek teeth and canines in order to avoid doing anything actively to encourage their mesial movement. The capping of the six lower fronts supplies adequate anchorage for generating the back thrust on upper teeth. When trimming the bloc out of contact with the distal contours of $\overline{3|3}$ one should remember to trim away inside the capping from the distal slope of the very cusps of $\overline{3|3}$.

To return to those deflecting upper blades ending thinly at their lateral extremities. When they drive the upper cheek teeth distally along

diverging lines the extremities of the blades must gradually cease to extend fully up to the contact areas. The more the ends of the blades fall short of the teeth interstitially the less direct will their distal thrust be. The direction of the thrust begins to veer a little more towards a buccal direction and less towards a distal direction. Periodically it is useful to remould the blades with cold-cure acrylic at the chairside, particularly when much distal movement is required following posterior extractions as described later.

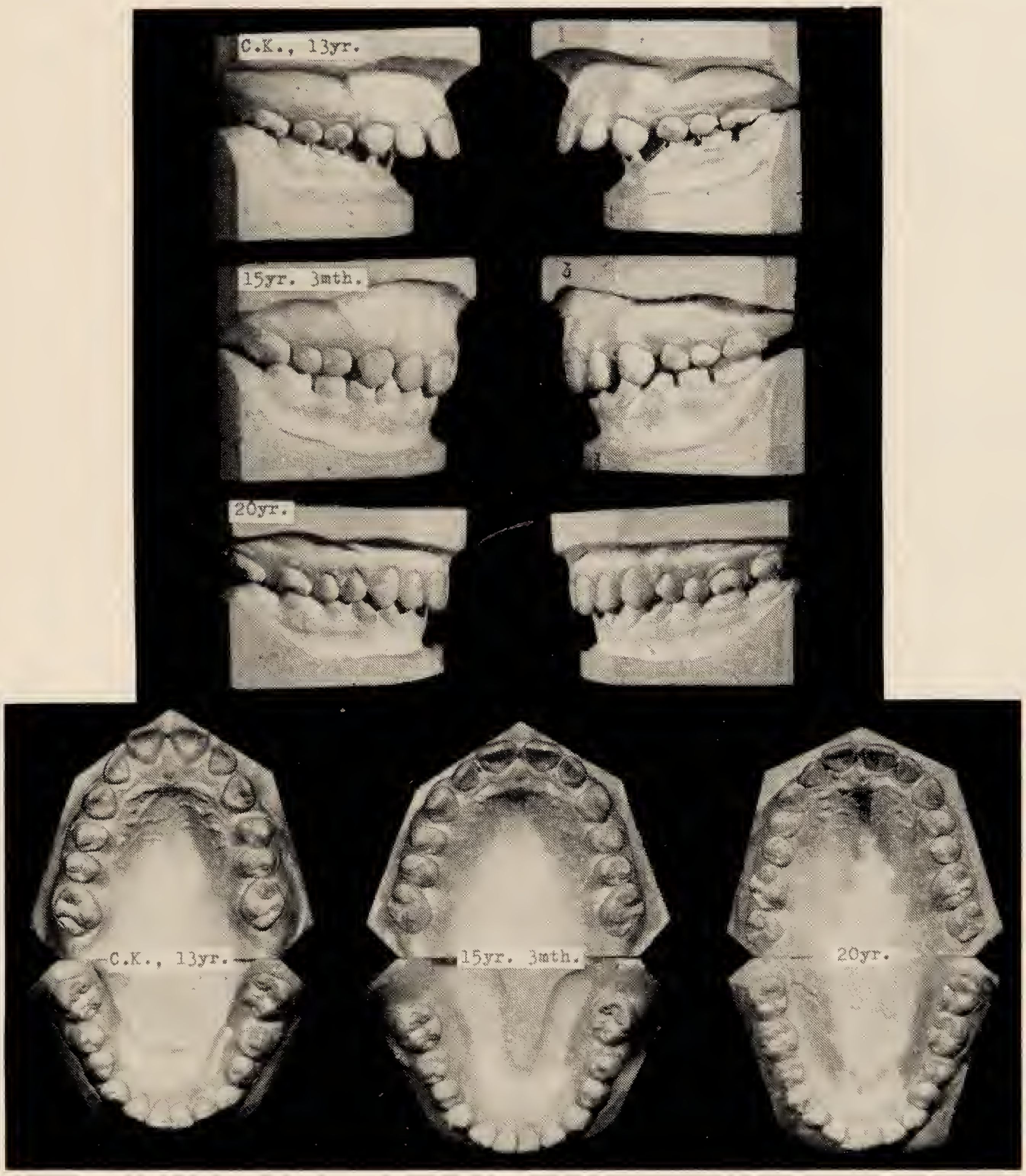

Fig. 4.—C.K. Overjet 15 mm. accentuated by early loss of all first molars. Four years 9 months out of retention at 20 years.

If treatment is started during the late mixed dentition stage it is useful to cut away the buffer areas against E|E when they start loosening and at the same time to add a smear of cold-cure acrylic to the buffer areas against 4|4. At the visit following the shedding of E|E you will find that 4|4 are moving back to take up the excess space which has become available. The opportunity is then provided for 3|3 to be moved more distally by a slight readjustment to the canine wires. You can see how necessary it is when constructing the bloc in the first instance to place the points of exit of the bow below and distal to the contact points of 43|34. Otherwise there is no opportunity to produce extra distal movement of the canines. Having obtained this movement the bow can be adjusted to contact the incisors a little more firmly.

There is no need to add temporary clasps for use in early stages to ensure that the bloc will stay in at night. The window makes it so readily acceptable. The bloc should be worn for not less than an hour towards the end of the day and at night.

At the time of first fitting and at not too extended intervals afterwards it is wise to ensure

that its posterior border is fitting flush up against the palate. If the mouth is opened quite widely the little finger can be inserted under the bloc and can reach back to the posterior border to check the fit there. Occasionally, a newly erupting tooth or a loose temporary tooth will be found to be preventing proper seating and a little local

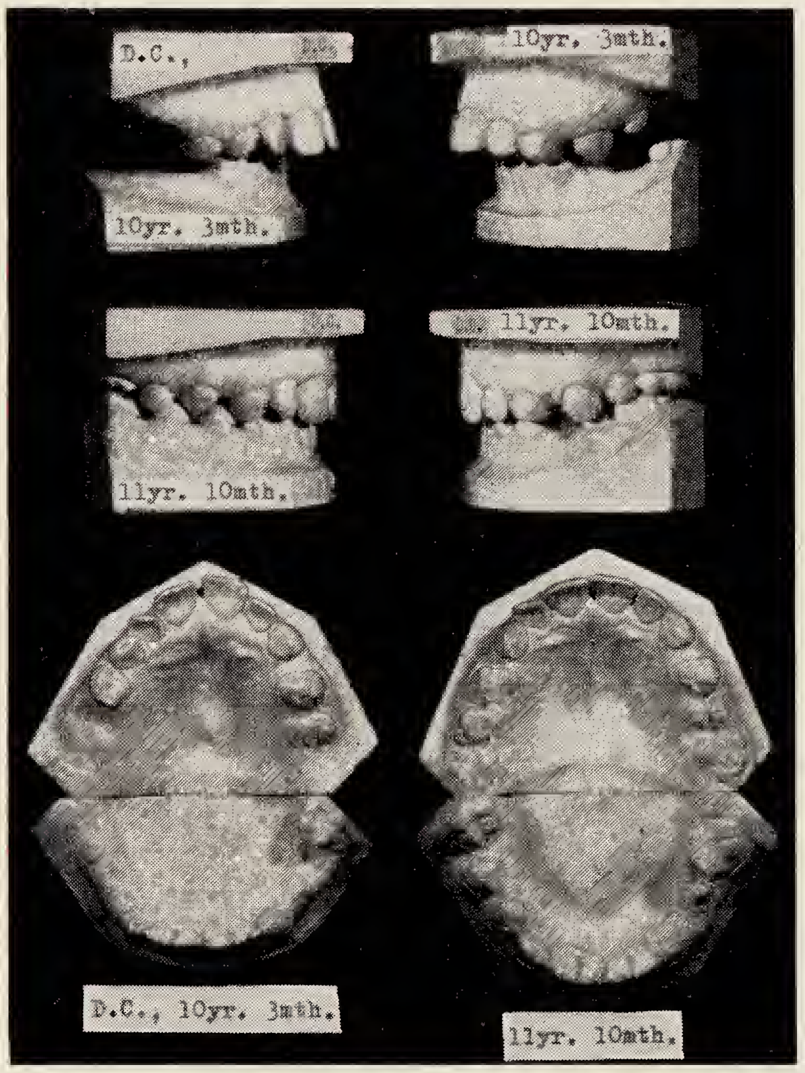

Fig. 5.—D.C. Early loss of deciduous molars and recent loss of $\underline{6|6}$, $\overline{6|}$. Toothless areas posteriorly no bar to treatment.

easing may be all that is necessary, but if there is no such cause there is no way of discovering the site of the trouble and one has to realize that the carefully planned buffer areas cannot be lying against the teeth properly and that it is a waste of time carrying on with the same bloc.

The working bite needs to separate the jaws a little more than the separation produced when the mandible is in the rest position. When Mr. B. V. Hewett was a House Surgeon at Guy's he investigated myographically under the guidance of Professor Tulley the action of masseter and temporal muscles when a monobloc gagged the bite just beyond the degree of separation assumed in the rest position. He demonstrated that the muscles not only showed excitations when the bloc was intermittently seated when the patient champed on it or swallowed, but there were also prolonged periods of tremulous excitation which resulted in the teeth receiving impulses from the bloc in the same sort of way, although with less vigour, that an electric bell is tapped by its vibrating hammer. This interesting study has not, I think, been published outside Guy's. If the bite is gagged to produce a separation less than is produced by the rest position the bloc is not necessarily ineffective because it is still fidgeted with and bitten upon, but some of its efficiency is lost by the absence of the ' electric bell ' mechanism.

It would be fair to adopt a generalization which postulates that the deeper the overbite the further does the mandible fall away from the maxilla in the rest position. Since the working bite needs to register a separation of the jaws a little greater than the separation at rest one finds in practice that the separation usually required between the cheek teeth varies somewhere between 3–10 mm. approximately, though on occasions it is more where the overbite is very deep.

There is no need, however, to be primarily concerned with the amount of separation when taking the working bite, for a clinically satisfactory amount is automatically determined if one adopts a rule-of-thumb as one registers the required forward bite. The mandible is advanced to bring the lower incisal edges very nearly as far forward as upper incisal edges with a separation of 1–2 mm. between their edges in the vertical plane. This degree of separation, incidentally, allows one to cap the six lower fronts without the capping obstructing the retraction of the upper fronts. One other point in taking the working bite, supposing a dentition is not symmetrically Class II. If the cheek teeth relationship is more Class II on one side the upper and lower centre lines will not coincide (assuming there has been no local drift). The lower centre line will be displaced to the side showing the greater degree of Class II relationship. Now does one correct this discrepancy between upper and lower centre lines? It would usually mean slewing the mandible by less than half the width of a lower incisor to bring the centre lines into the same sagittal plane. I find that one can make this slight shift with advantage. In early days I thought it might upset the comfort and the whole working of the appliance, but it does not seem to do so.

The following cases bring out some of its uses where one is dealing with Class II, division 1 dentitions which in varying degrees depart from the ideal ample arches in Class II relationship. *Fig.* 4 shows a Class II, division 1 dentition not wildly different where all four 6's had been extracted 4–5 years previously through caries, and where the overjet was as much as 15 mm. The incisor apical relationship was a mild Class II. The lips looked as though they were potentially just competent. I figured that the arches would not have been very short of room if the 6's had not been extracted and that it would be possible to move the whole upper arch distally without meeting too much resistance. One appliance was used over a period of 27 months, during which time the patient was seen eight times.

Fig. 5 shows a more recently mutilated Class II, division 1 dentition where $\underline{6|6}$ and $\overline{6|}$ had been extracted together with several temporary molars. Despite the handicap of toothless areas posteriorly a monobloc corrected the overjet and ensured a Class I premolar relationship in 19 months. One had to hollow out the bloc as achieved, but rather more slowly, by extracting the four D's. The next step was to insert a monobloc capping the lower incisors and get it comfortably settled in for a month or two and to see the beginnings of improvement in arch relationship. $\underline{6|6}$ were then extracted. From then on it becomes easier for the same bloc (after it has been

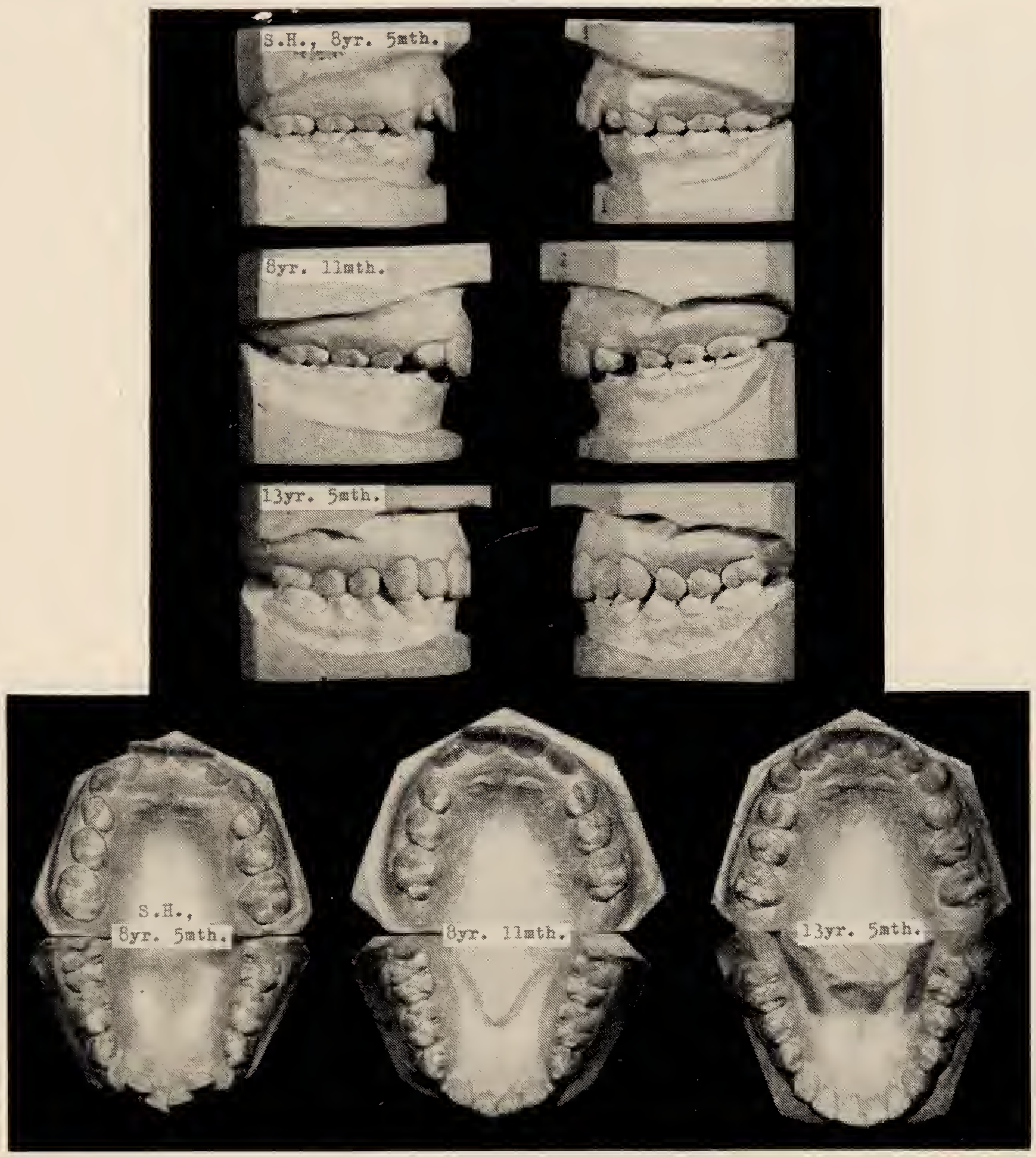

Fig. 6.—S.H. Serial extractions (four deciduous canines, staggered extractions of four first molars). Bloc used after natural improvement of incisor alinement subsequent to the extraction of deciduous canines.

teeth erupted and progressively remould the areas with quick-setting acrylic to drive the upper premolars distally to an adequate degree.

Fig. 6 shows a Class II dentition where the arches were too small to accommodate all teeth in satisfactory position. The 6's were of doubtful quality.

The incisor apical relation was about normal and the lips mildly incompetent. The first step was to remove the four C's and await natural improvement in incisor alinement, not of course in incisor relationship. For those who do not like extracting C's early the same result would be smoothed back in the region of the extracted 6's for comfort's sake) to thrust $\underline{ED|DE}$ distally. More room is being created for the reception of $\underline{3|3}$, and the deciduous molars are getting nearer to Class I relationship. It is necessary at this stage to adjust the bow just out of contact with the incisors to concentrate the intermaxillary traction solely on the upper cheek teeth. When the distal border of $\underline{E|E}$ has moved back enough to be about flush with the distal border of $\overline{E|E}$ the lower first molars can be extracted and again the bloc appropriately smoothed posteriorly. One is generally able to extract $\overline{6|6}$ about 6–9 months

after $\underline{6|6}$ have gone. With the bloc trimmed away from the distal contours of lower deciduous molars they are now free to drift distally and to start providing more room for $\overline{3|3}$. The lower premolars will start drifting distally while still straightforward monobloc therapy. I need hardly say that the presence of all successional teeth should be confirmed at the outset and that the developmental position of $\overline{5|5}$ should be such that neither is likely to slide out distally from a

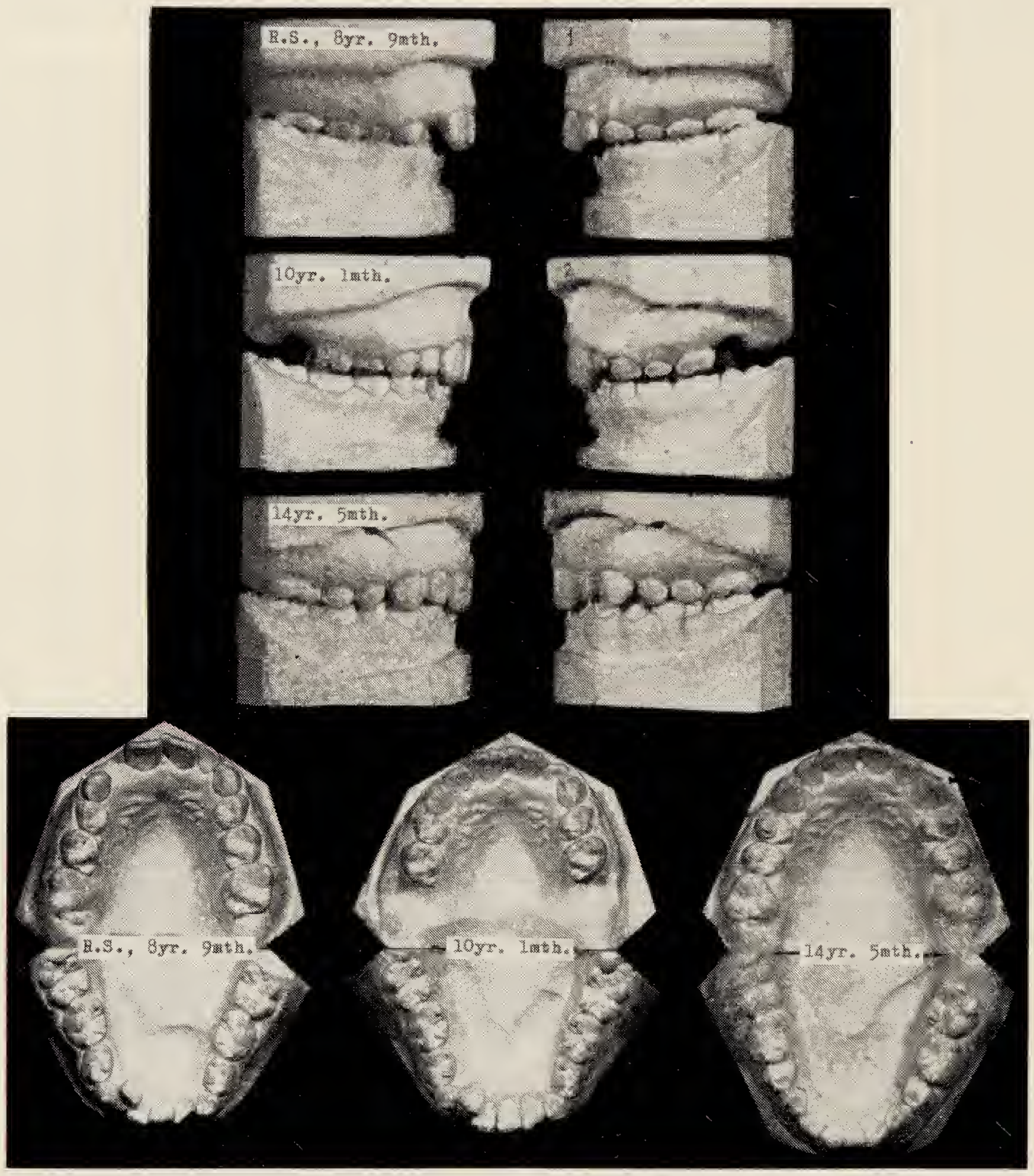

Fig. 7.—R.S. Similar to dentition in *Fig.* 6 treated with staggered extraction of four first molars. $\overline{E|E}$ not shed in models at 14 years 5 months.

unerupted in face of the crowding in the canine regions. Although this will improve the chances of alinement of the lower canines you can appreciate it reduces the chances of ultimately obtaining a Class I premolar relationship. It is now that the deflecting blades are regularly remoulded with quick-setting acrylic to step up the distal thrust on $\underline{ED|DE}$, and when $\underline{4|4}$ erupt there is more remoulding and more distal thrust exerted.

Although the necessary sequence of events is not difficult to appreciate, the handling of this type of treatment is not particularly easy and it would be as well not to choose to treat a case of this nature without prior experience in more retained lower second deciduous molar. If faced with this sort of situation it is usually possible to regularize the position by extracting the overlying lower deciduous molar when $\underline{6|6}$ are extracted. The distally sloping lower second premolar is then edged forward by mesial migration of the lower first permanent molar before the time arrives for the extraction of $\overline{6|6}$.

Fig. 7 show the same sort of dentition where the staggered extraction of first molars was performed, but the incisor crowding was not first relieved by extracting the deciduous canines. A complication now arises because the capping of the lower incisors would fix their irregularity unless the capping is progressively modified by

a combination of easing and of adding cold-cure acrylic labially or lingually as the case may be and of permitting the distal spread of the teeth. An alternative is to refrain from capping, and so allow incisors to procline temporarily knowing that when they ultimately return to their resting inclination their chances of imbricating again will be reduced, because posterior extractions will have allowed premolars and canines to drift distally. There is some disadvantage, however, in allowing temporary proclination of lower incisors. Crowding in $\overline{3|3}$ regions is temporarily reduced and the longer it is reduced the less early will the canines start edging $\overline{4|4}$ distally.

In Class II, division 1 dentitions where there is only border-line crowding of the lower incisors at say 10–11 years one takes it as fairly certain that if third molars are present the crowding will increase. There is also the presumption that when the Class II, division 1 relationship is corrected the upper incisors will ultimately become at risk as lower incisors deteriorate. All this is going to happen unless four teeth are extracted, and yet the extraction of the four first premolars would seem to provide more room than is wanted when there is little more than a suspicion of lower incisor crowding. Under these conditions I find it best to combine the use of a monobloc with the extraction of the four second molars. One wants to know that all third molars are present. I doubt whether it is necessary to be much concerned with the future size of the third molars though if their crowns are veritable pimples one would have to think again. If third molars are not jammed far back in the adult mouth they are capable of long life even if they have only one root. Where they are jammed back one finds that both third and second molars tend to show an unhealthy periodontal condition in middle adult life. It is pretty safe to predict that the final position of $\overline{8|8}$ will be satisfactory, providing their developmental tilt in X-rays is not more than about 45° mesial to the long axis of $\overline{7|7}$ and providing one can extract the lower second molars at about 12–13 years. If one extracts at say 17 years there is an increase in mesial tilt rather than a decrease. I know it is arguable whether the erupting third molars make a contribution to late incisor crowding. I think that the normal gradual increase in the angle between the long axes of upper and lower incisors is an important factor in the crowding which develops, but I cannot dismiss the probability of third molars with insufficient space pushing forwards. Remember how crowded lower second premolars, providing they are vertical in X-rays, slowly and surely open up enough space for themselves, erupt fully to occlusal level and push other teeth out of line in the process. In addition to the probability of reducing the degree of lower incisor deterioration by extracting lower second molars as soon as they erupt, there is the humanitarian aspect of avoiding possible impaction of third molars which I, being a coward, rate quite highly. I would not view with indifference the proposal of having my third molars surgically extracted at any age. The sum of misery and expense attached to such third molars tends to be overlooked in the orthodontic world.

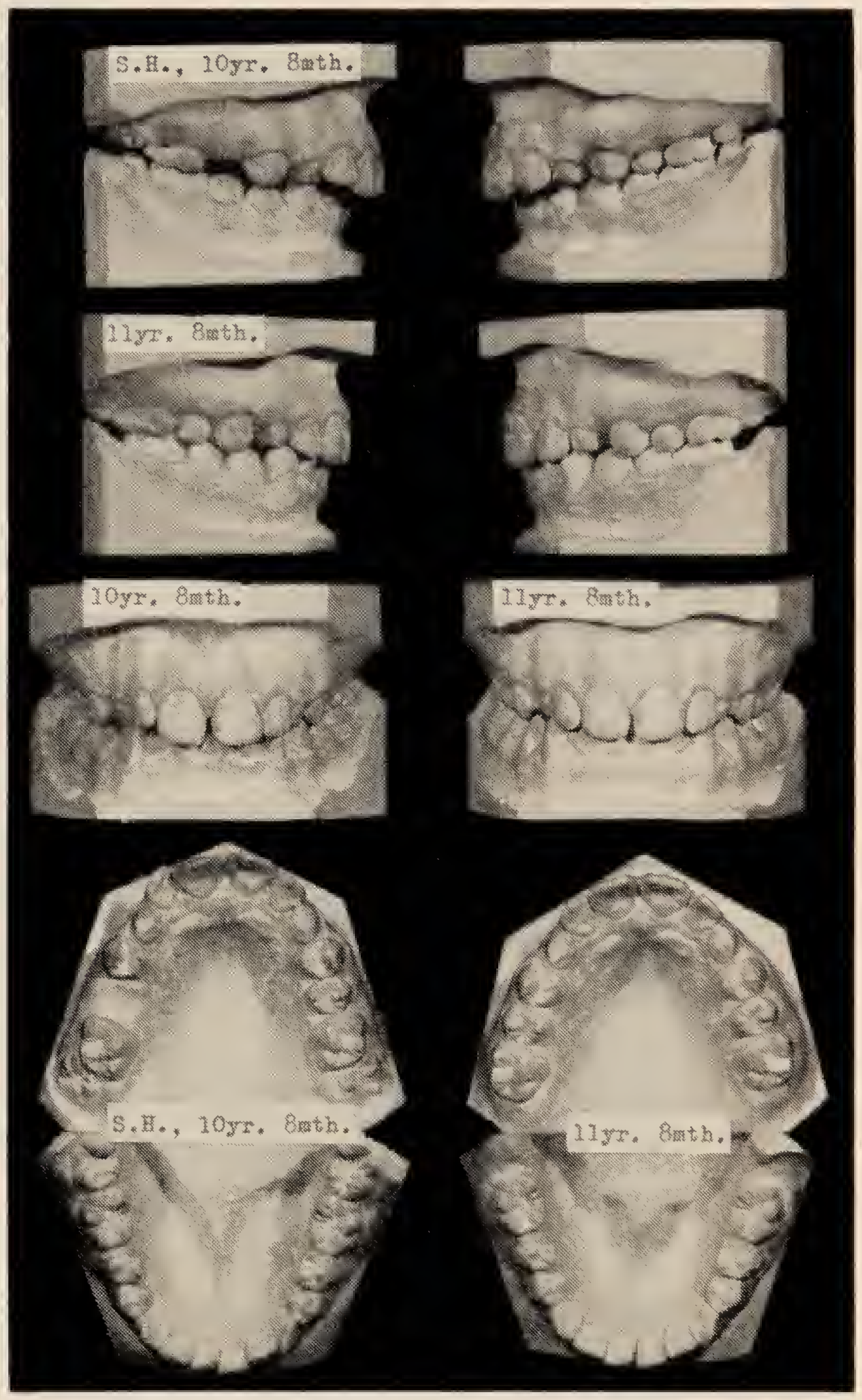

Fig. 8.—S.H. Mild crowding in lower incisor region treated by prior extraction of the four second molars. Half-unit Class II on right side, less so on left. Upper and lower centre lines becoming more coincident.

You can appreciate how the loss of $\underline{7|7}$ provides an easy passage for the distal movement of upper cheek teeth. The extraction of $\underline{7|7}$ is no new manœuvre. I can remember a demonstration on a Clinical Day at the Royal Dental Hospital when Professor Ballard, then a young registrar, showed a series of Class II, division 1 dentitions corrected with a fixed labiolingual technique following the loss of $\underline{7|7}$.

Fig. 8 shows the sort of dentition likely to benefit by the loss of all second molars. It is mildly crowded in the lower arch anteriorly. Third molars are present in X-ray, and the

developmental tilt of $\overline{8|8}$ is not more than 45° mesial. The eruption times are early. All second molars were extracted and a bloc used for twelve months. The occlusion was a half-unit Class II, division 1 relationship on the right side by 11 years 11 months, before $\underline{7|7}$ had erupted. If treatment had been delayed until after the extractions the upper arch would have moved back more readily and the slight final crowding of the lower incisors might have been less had they

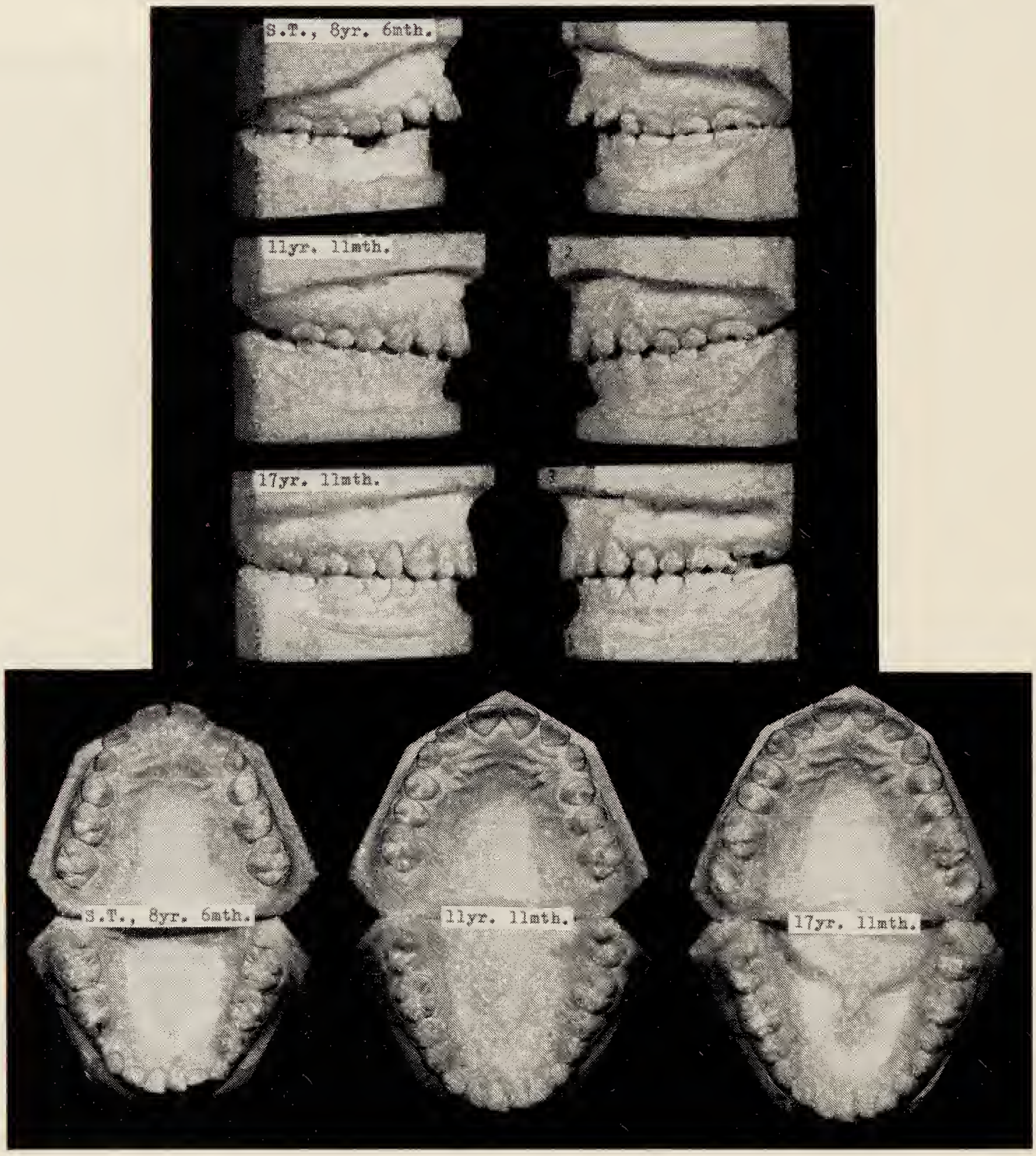

Fig. 9.—S.T. Mild crowding in lower incisor region. Half-unit Class II, division 1. The four second molars extracted after correction of cheek teeth relation which was completed at 11 years 11 months.

and less so on the left. You will notice that the centre lines became more coincident after treatment as a result of making them coincide when taking the working bite.

A more extended history of a Class II dentition with slight lower incisor crowding where the four second molars were extracted is illustrated in *Fig.* 9. The position assumed finally by the third molars is shown in *Fig.* 10. Giving way to parental pressures the treatment was started earlier than needed, earlier in fact than was desirable. The arch relationship was corrected not been used for anchorage while the full compliment of lower teeth remained.

When the arches are not only in Class II, division 1 relationship but the anterior teeth are obviously crowded I have not had much success with monobloc therapy where a decision has been made to extract the four first premolars only. Alinement and retraction of upper fronts can be obtained with separate appliances of choice. The lower fronts not infrequently can be left to aline themselves. When one comes to the stage of correction of the Class II cheek teeth

relationship with the monobloc the back thrust on upper cheek teeth is not particularly effective on account of the 'stacking'. in 87|78 regions. There is considerable resistance to a back thrust on 65|56. I have heard it asked, why bother while the lower fronts are unbuttressed. But supposing you get over this difficulty by closing the lower residual spacing by bringing 65|56 forward into Class 1 relationship and thus buttressing the lower fronts too. Well, it looks

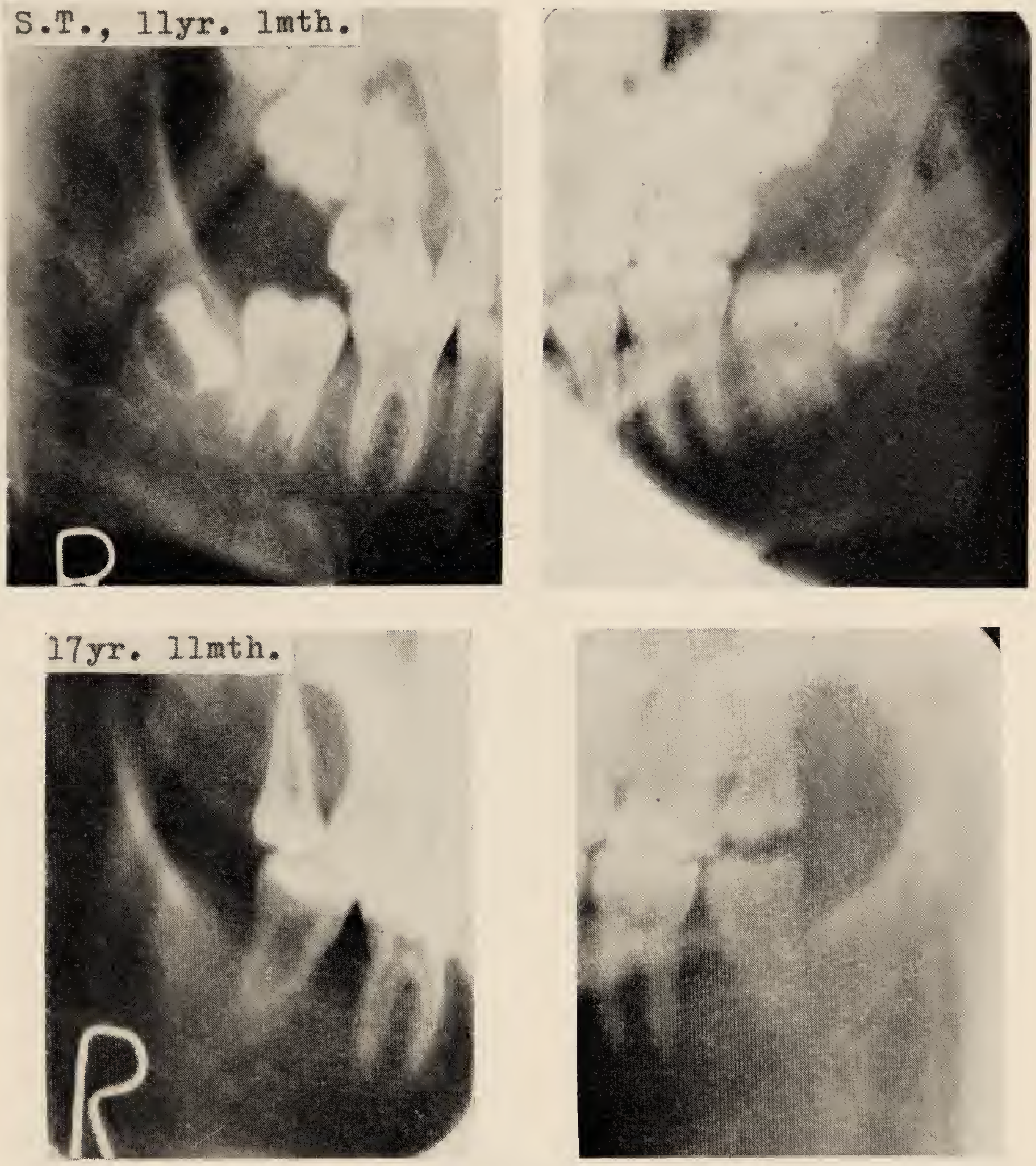

Fig. 10.—S.T. Position of third molars after extraction of second molars at 12 years 6 months.

further. There has been very considerable improvement, 3|3 have been moved back in contact with 5|5 and 21|12 retracted, and although there is some residual spacing behind 3|3 it will reduce naturally in time. This is a reasonable attitude only providing the patient doesn't mind wearing a retention plate while drawing the old-age pension. There is no stability in the result, not, I would like to suggest, because the lower fronts are unbuttressed, but because there is no residual spacing in the upper. The danger lies in having the upper fronts buttressed satisfactory for a while, but then you see imbrication of the lower fronts developing once again and a secondary deterioration comes about in the upper fronts. In my experience it is not wise to restore lower contacts early in an arch which has previously shown inadequate growth potential. I think one needs to be thankful for some lower residual spacing and to *unbuttress* the upper fronts by moving upper cheek teeth back. Now this is not easy unless you proceed to extract two more teeth at the back of the upper arch. If you extract 7|7 a monobloc is then effective.

In *Fig.* 11 the four first premolars had been extracted some 18 months previously in the expectation, I gathered, that things might right themselves! The extent of the residual spacing suggests that the size of the arches was always pretty satisfactory and that a distal thrust on upper cheek teeth would be effective to correct had nearly gone. The whole exercise seems to be a justification for not being concerned about some residual spacing at 13–14 years, providing the spacing has been made at least equal in upper and lower arches by moving upper cheek teeth distally into Class I relationship.

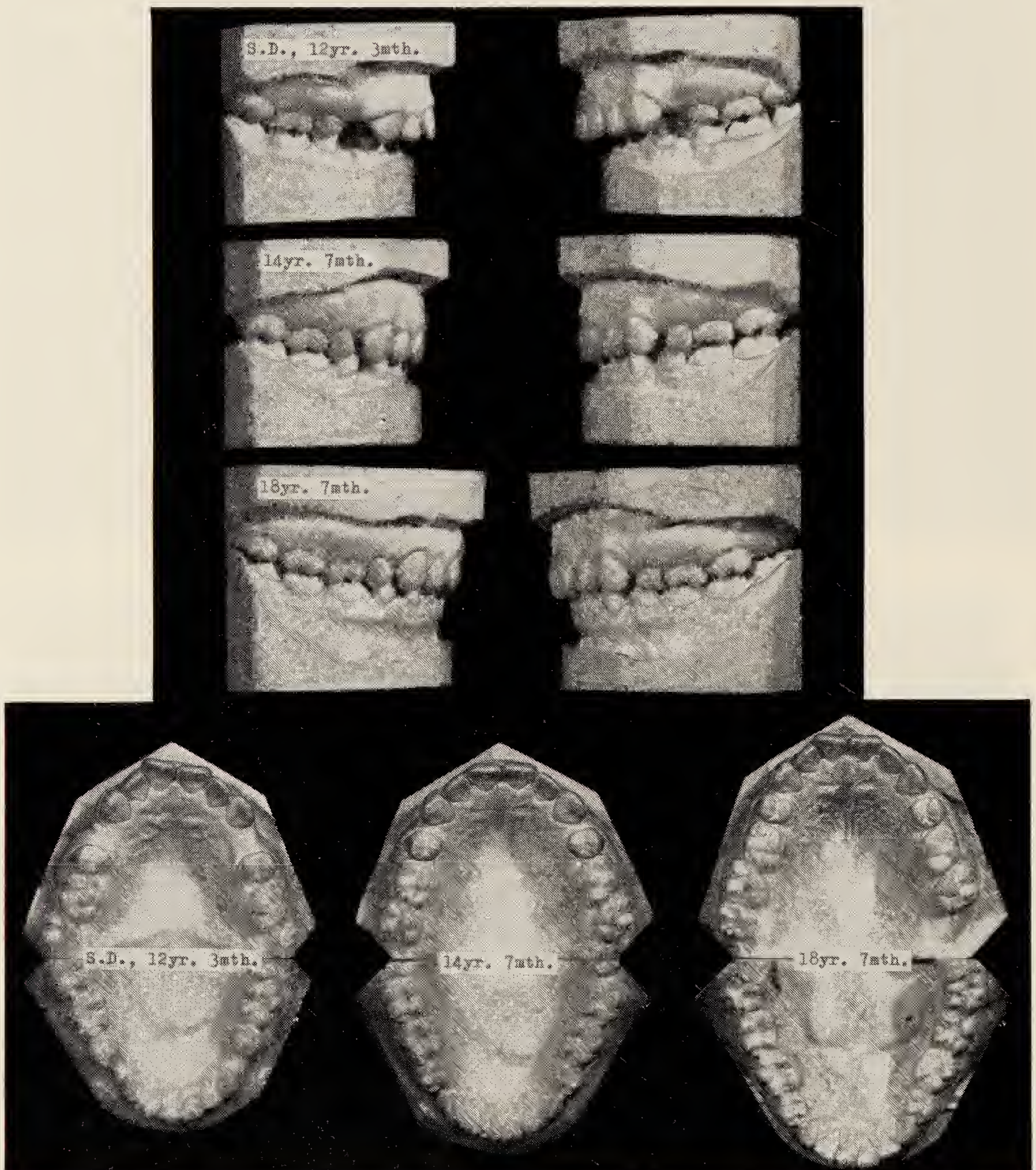

Fig. 11.—S.D. Patient presented with four first premolars extracted 18 months previously (? necessity in view of absence of much mesial drift of cheek teeth). Four years out of retention at 18 years 7 months.

the arch relationship. A bloc was inserted and the correction made by $14\frac{1}{2}$ years of age. There was still more residual spacing in the upper arch than in the lower and it seemed to be of reasonable extent for the age. Four years later the lower residual spacing had gone. All third molars except |8 had erupted and the lower fronts were reasonably good. Upper residual spacing

The bloc comes in useful also for those Class II dentitions where one or more upper cheek teeth are in complete buccal relation to their opposite numbers. You have of course to ensure that conditions are such that room can be acquired for their palatal movement. One needs to add a fairly rigid wire, to make close contact with the upper teeth concerned on their buccal side and at

the same time to ease the bloc in such a way that the teeth can move palatally while still being tapped distally. In making the bloc in the first place make it thick enough locally to allow for this easing without puncturing it. Having thus set the conditions for appropriate upper movement the opposing lower teeth can be buttressed buccally with additions of quick-setting acrylic

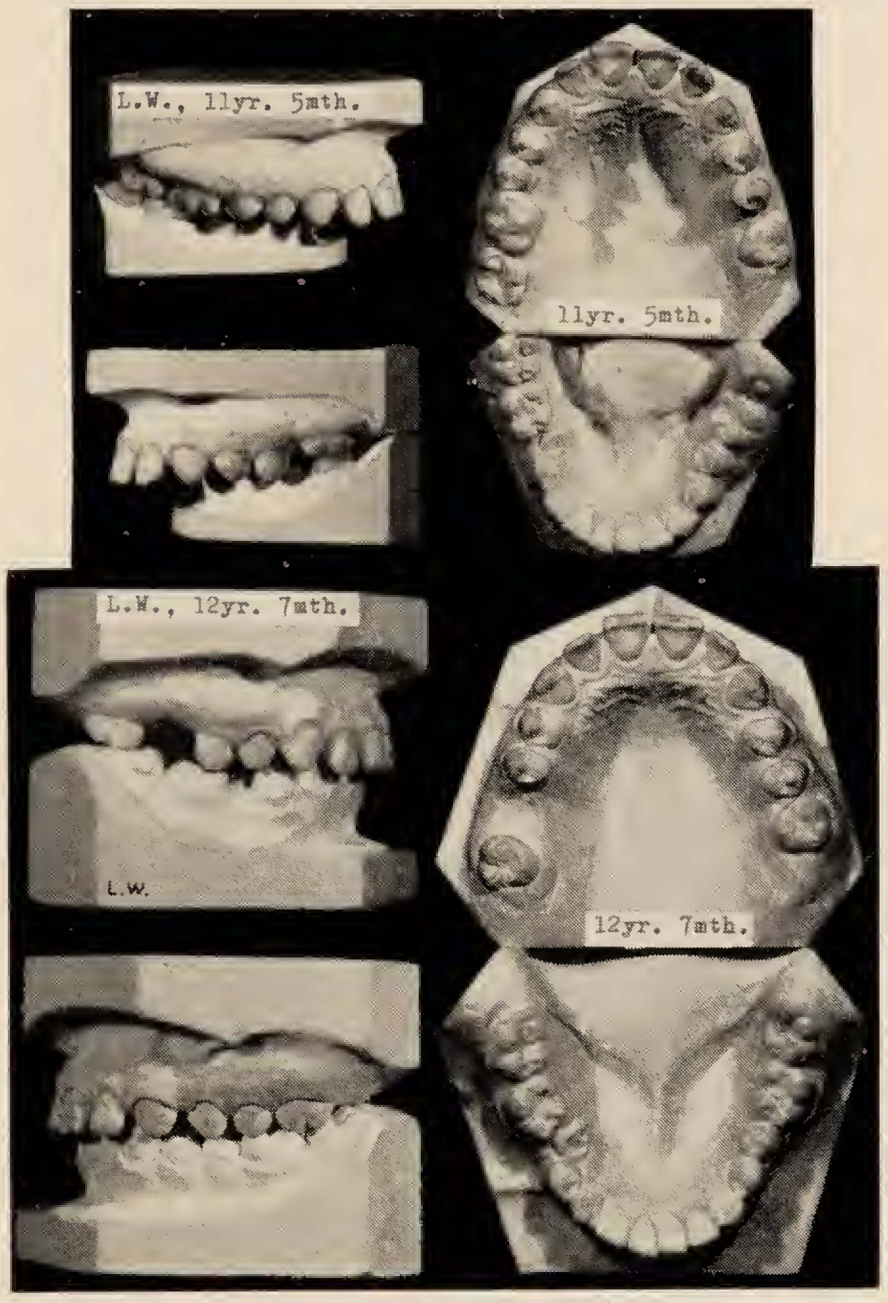

Fig. 12.—L.W. All upper cheek teeth except $\underline{7|}$ completely external to lower teeth. An abscess on $\underline{6|}$ caused plans to extract $\underline{7|}$, $\overline{7|7}$ to be changed to the extraction of $\overline{6|7}$. $\overline{5|}$ to be uprighted with the bloc.

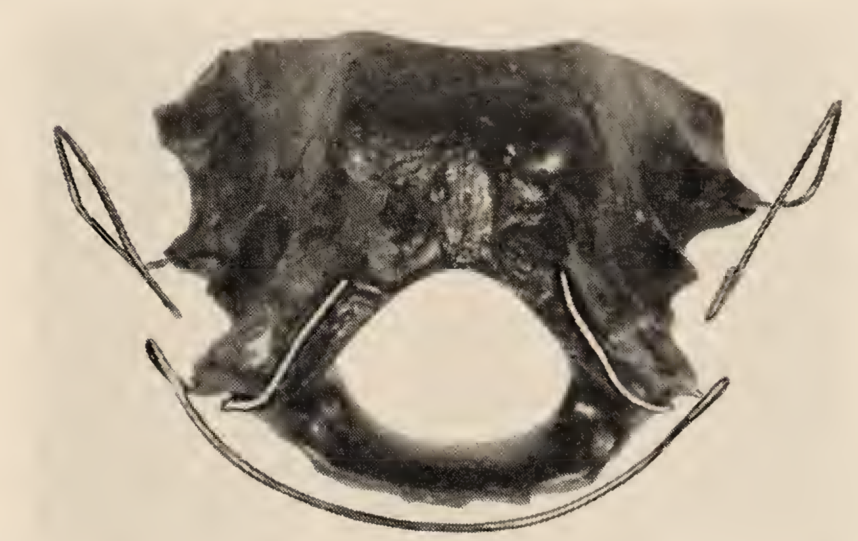

Fig. 13.—Monobloc with buccal wires used to correct buccolingual and anteroposterior relations of L.W.'s dentition.

to their facets on the bloc. Each time the lower additions are made the upper wire is adjusted to make slightly firmer contact. *Fig.* 12 shows a Class II, division 1 dentition where the only cheek teeth to meet on their occlusal surfaces were $\underline{7|}$ and $\overline{76|}$. All other upper cheek teeth were completely buccally related to lower teeth. In 11 months correct buccolingual relations were restored with the monobloc shown in *Fig.* 13. It was then hoped to extract $\underline{7|}$ and $\overline{7|7}$ and to move $\overline{5|}$ into the arch with additions of acrylic. Unfortunately $\underline{6|}$ developed an abscess and had to be extracted. It now is advisable to extract $\overline{6|7}$ and to upright $\overline{5|}$.

In conclusion I hope I have been able to demonstrate to your satisfaction that monobloc therapy can be usefully applied to Class II, division 1 dentitions of varying complexity.

DISCUSSION

Mr. A. J. Walpole Day said that the President had made three points which stood out very clearly. Firstly, those present understood that he liked a good soft-tissue environment. A very big factor brought out was that of decrowding, either choosing a case where there was no crowding or, if there was crowding, extracting teeth. The third thing was that, having successfully corrected the occlusion in some cases without extractions, the President then proceeded to take out second molars because he knew very well that when the third molar erupted, more crowding would result and the case would probably relapse. He asked the President what information and instructions he gave to the patient about the monobloc.

The President said, with regard to crowding, he had seen so many dentitions over a long period that this late crowding had been a great fear with him and he had learnt to try to forestall it.

On the question of introducing the monobloc to the parents he told them that the child would be relieved of the necessity of having something in the mouth all the time. It would be loose, but there was no need to fear that it would be swallowed. He said that because it was loose it would not always stay in, especially during the first week or two.

Mr. B. B. J. Lovius asked four questions. He said firstly that the President had not talked about expanding the arch before treatment. This had been advocated by several people. Secondly, had he found any difference in response with the obtuse-angle mandible compared with someone who had a lower Frankfurt-mandibular-plane angle? Thirdly, was he to understand that the President used basically the lower incisors as the anchorage, due to the unconventional way in which he trimmed the appliance. Fourthly, had this been used on any adults?

The President, in reply, said that he did not expand first because the ' bloc ' drove the upper cheek teeth back on diverging lines. There was no need to expand.

With regard to the Frankfurt-mandibular-plane, the higher it was, the nearer you were getting to concomitant soft-tissue troubles. The wider it was, the less rosy was the outlook, not necessarily for a monobloc, but any sort of appliance. That was why he said that the monobloc had no magical properties. Regarding anchorage it was from the six lower front teeth whenever possible; there were periods when you could use only four, but six were used on all other occasions.

He had treated adults, but would not advocate it for very severe cases.

Mr. F. Allan said that the monobloc is, of course, an appliance which utilizes the principle of reinforced anchorage by using the occlusal surfaces of both arches and also the principle of reducing the resistance to mechanical movement by separating the arches during the action of the appliance. When, however, the appliance is not worn, the labial segments are moved in opposite directions. Thus even this appliance, like all other conventional retraction appliances, is a periodontal menace and the treatment period is being prolonged.

The President replied that whatever appliance was being used, if it was being used to try to defeat inherently adverse muscular pressures, it was wrong to use it. In the cases he had done, he had not found any adverse periodontal troubles arising, or resorption. Whatever armchair philosophers said, in practice one did not get loose teeth and monobloc therapy was quick.

Mr. H. Lester asked the President if he used the appliance in Class II, division 2 type malocclusions. If so, what success had been achieved?

The President said that his experience of Class II, division 2 treatment with monobloc was too recent for him to comment. All he could say was that at the E.O.S. Congress in Stockholm, eight months ago, Dr. Kjellgren gave a demonstration showing late results of Class II, division 2 treatment with monoblocs. His end-results were in Class I relationship, but they frequently showed a tendency to crowding. He could not help thinking it would have been helpful to have extracted second molars.

Mr. H. L. Leech said that the President had stated that the appliance was a simple one; however, in view of the fact that it had to be constructed very accurately would he say that this was a particularly suitable appliance to advise a general dental practitioner to use?

The President said that while one had to be careful in constructing the appliance, he did not think a lot of expertise was needed.

Mr. J. Alexander asked if the President had ever used an anatomical articulator to get the bite rather than taking a working bite in the mouth.

The President replied that he had not done so. He doubted whether one ought to do that. He thought it should be taken in the mouth. It was not a difficult procedure.

Mr. S. G. McCallin said that he had used the ' window ' the President described. He had been fearful initially that it would result in the overbite increasing. One or two of his patients did suffer an increase in the overbite as the upper anterior teeth were tilted back, but the majority did not. He had recently expanded the maxillary arch in most of his cases where he was going to use a monobloc. The response one obtained was very much more rapid following expansion than it was without it.

The President said that initially, when he started using the monobloc, he used to teach that one should expand first on the score that it led to more rapid results. One had to allow for a little collapse with attendant special trimming, and if the change-over was not smooth the bloc soon would not be seated properly. If you did not expand first, you still succeeded without undue delay.

On the question of increasing the overbite, he did not get an increase. It would be found that when capping, if the thickness of the cap was not more than about 1–2 mm., as one progressed, the upper front teeth were sitting on the top of the cap and were not over-erupting.

Mr. B. H. Miller said that some benefit could be wrested from prior expansion of the maxillary arch in cases which had a narrow upper intercanine width. Expansions seemed to unlock the canines. With regard to treatment of Class II, division 2, he thought that there was danger in not proclining the upper incisors because he had seen cases which turned into Class III through not doing that.

The President said that Mr. Miller was assuming the lower jaw would grow forward because he unlocked the lower canines. All he had to do was move the upper canines distobuccally.

Mr. H. Wilson asked if the President ever used the appliance without trimming. He personally could never correct midline discrepancies with the monobloc.

The great advantage in extracting second molars was the reduction of tilting and production of a far more efficient occlusion than if premolars were extracted.

The President agreed. It was nice to have intact cheek teeth right from the canines to the molars.

With regard to trimming, if one did not trim and if because of that the cusps of the teeth were gripped the upper arch would be prevented from widening, so it would become relatively narrower.

SOME INDICATIONS FOR THE USE OF FIXED MULTIBANDED APPLIANCES

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Royal Dental Hospital of London; Coventry and Warwickshire Hospital, Coventry

In this country, for basically socio-economic reasons, orthodontic appliances tend to be of the removable variety, but some fixed therapy has been used to deal with certain specific situations, particularly in the dental teaching hospitals.

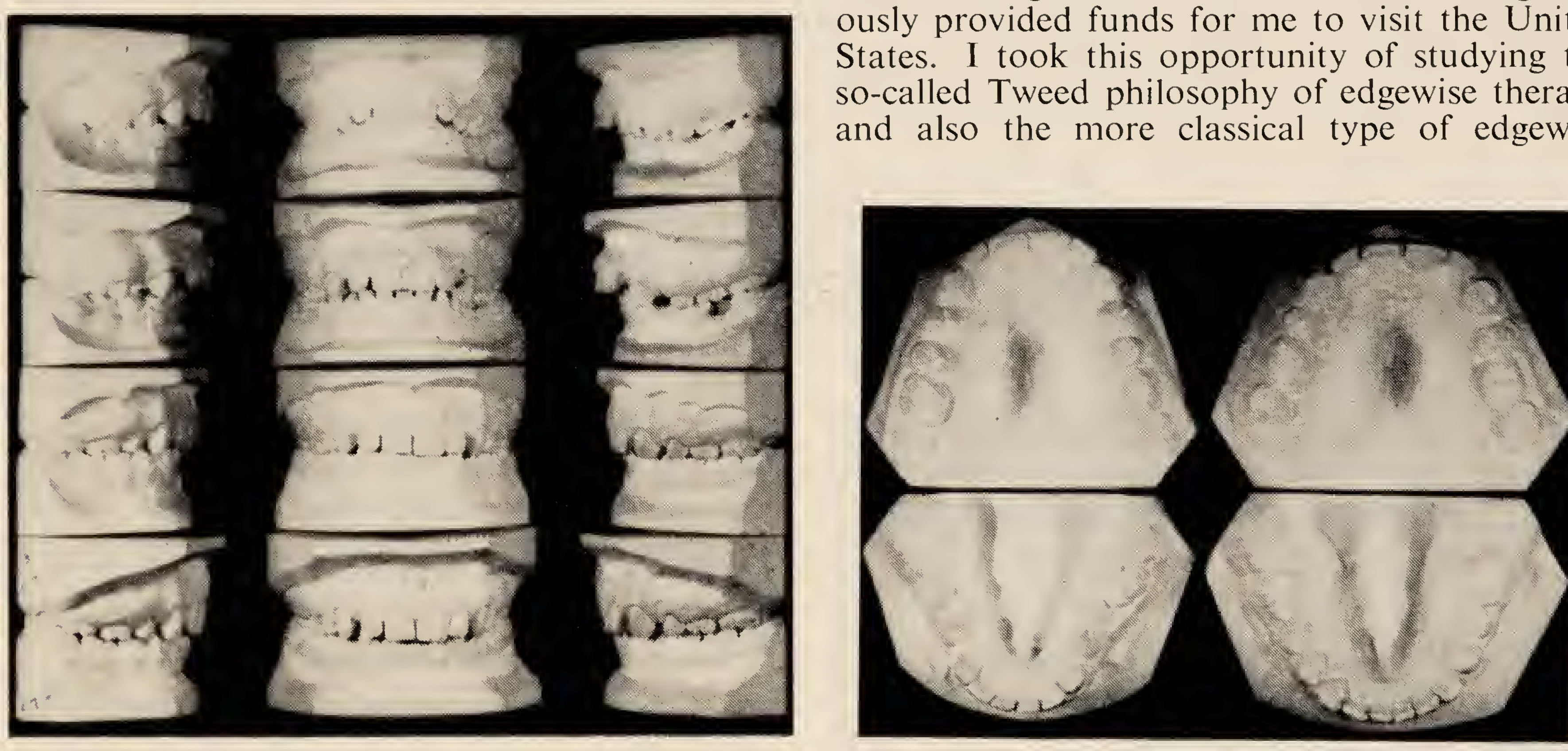

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Fig. 1.—*Patient S. I.* A, Models are shown from above downwards at the beginning of treatment, after lower arch expansion, at the end of retention, and 18 months out of retention. B, Occlusal views before treatment and 18 months out of retention.

The main type of appliances to which I refer are:—

1. Labiolingual with the various spring attachments such as originally described by Friel (1933), Mershon (1927), Rix (1938), and others.
2. Round-wire multibanded appliances as described by Hill (1954) and the present author (Briggs, 1960, 1962) amongst others.
3. Johnson twin-wire appliance such as described by Mills (1959) in this country and by Shepard (1961) in the United States.
4. Edgewise arch mechanisms as used by Tweed and his co-workers and described by Halden (1958) to this Society some years ago.
5. The edgewise arch mechanism of Angle (1907).
6. Light-wire appliances of Begg (1961) and Jarabak and Fizzell (1963), which have also been used with various degrees of success in this country.

It was realized that our knowledge of the edgewise technique was deficient and some six years ago the Royal Dental Hospital and the British Postgraduate Medical Federation generously provided funds for me to visit the United States. I took this opportunity of studying the so-called Tweed philosophy of edgewise therapy and also the more classical type of edgewise treatment as originally described by Angle (1907) and practised by Brodie, Renfroe, and the other staff at the University of Illinois in Chicago.

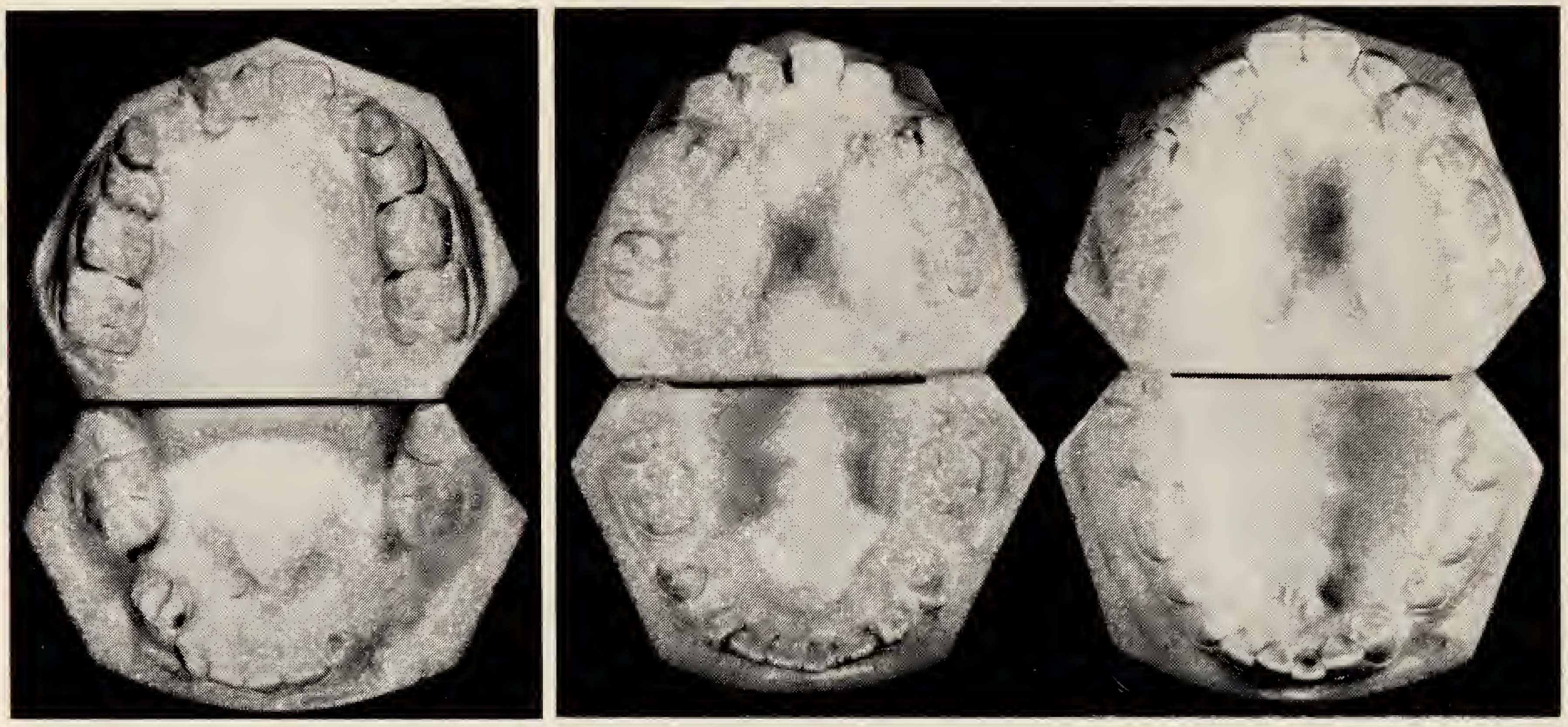
On arriving in the United States my own ideas tended to converge with Tweed, mainly because my training in the United Kingdom had conditioned me to regard extractions as an almost inevitable concomitant of orthodontic treatment. Even so, I was struck at the time by the number of cases which were treated with apparent stability by non-extraction techniques, cases which would certainly have suffered the removal of four premolar or molar units in this country.

Latterly, the Begg light-wire technique and its various modifications, usually with another operator's name attached, have become popular in the United States and may well do here. It is

Given at the Meeting held on 14 March, 1966.

the purpose of this paper to discuss briefly some indications for the use of various types of fixed appliances and to show a few cases treated by each in an attempt to illustrate the points made.

these with considerable success on many occasions when a prolonged attempt at retraction with a removable appliance has failed. These ingenious appliances were described in the



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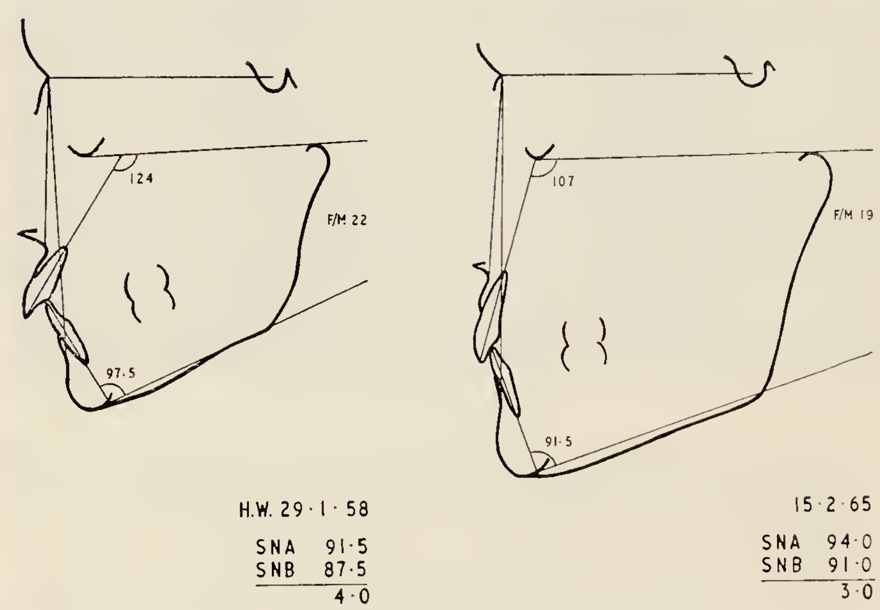

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Fig. 2.—*Patient H. W.* A, Occlusal view of models showing erupted supernumerary in midline. B, Occlusal view of models before and after multiband round-wire appliance therapy. C, Models from above downwards, showing the initial condition, commencement of round-wire appliance therapy, in retention, and two years out of retention. D, Lateral skull tracings before multiband treatment and two years out of retention.

Perhaps it is logical to mention first the most simple type of fixed appliance, which is the labiolingual appliance. I have found this appliance of very considerable value in certain specific situations, and in this context I would quote the retraction of reluctant upper canines and also the correction of the cross-bite commonly seen in the premolar region in a few Class II cases. Rix (1938) many years ago described sliding canine retractors on a palatal arch. I have used *British Dental Journal*, and could be used equally well with a fixed or removable appliance. A criticism commonly levelled against this technique is that the anchor molars will be brought forward, but I have not found this to be the case provided care was used in the construction of the appliance and in ensuring that the point of application of the canine spring was correct. It is essential that the palatal arch be firmly attached to the molar band and that the canine

sliding spring be not over-activated, particularly in the early stages. I would illustrate the latter example with my first case (*S.I.*) where as the first stage of treatment the cross-bite was eliminated with a lower lingual arch bearing finger springs attached by Rix's method of wrapping the fine wire around the right-angle of the U-loop. The patient, a boy (*S.I.*), born on 3.4.48, presented with an Angle Class II, division 1 malocclusion on a Class II dental base (*Fig.* 1A). The swallowing action was tooth apart, but there was no tongue thrust. There was a cross-bite on the left hand side. The lower right first permanent molar was missing and the lower left was extremely carious.

In January, 1962, a lower lingual arch was fitted in 0·8 mm. hard stainless-steel wire with bands on the lower first permanent molars and fine-wire springs attached to move the premolars buccally. The cuspal lock in the buccal segments was relieved with an anterior inclined plane on the upper removable appliance. This phase of treatment was completed in May, 1962, and was followed by a more sophisticated appliance to correct the incisor relation. I will refer to this next phase of treatment later. The amount of expansion which occurred and remained stable after retention can be seen in *Fig.* 1B.

In this country the most popular of the so-called multibanded appliances is derived from that described by Hill (1954) and taught for many years at the Royal and Eastman Dental Hospitals. The principle of controlled anchorage is freely used and all teeth involved in the tooth movement are banded, with the possible exception of the lower incisors. It is my opinion that the omission of lower incisor banding is good because the anchorage obtained from them is minimal and if they are not banded the proclination which almost inevitably occurs in treating a Class II case ceases to be a problem. This system of therapy is used to best advantage when extractions are necessary in both upper and lower arches and when Class II or Class III elastics are to be worn. The advantage of this technique is that it is straightforward to learn and manipulate. Apical movement is, however, difficult or impossible. It is also difficult to avoid a certain amount of tipping and rolling of the anchor molars. By the term ' anchor molar' I mean the last standing banded molar tooth, which in this system of treatment would normally carry a buccal tube. The following case shows the possibilities of treatment. It was treated by myself very early in my fixed appliance career and treatment extended over a prolonged period. I think this was due mainly to my own lack of expertise, but I am showing it because it illustrates several interesting points. The patient, a boy (*H.W.*), born on 22.1.46, had an Angle Class II, division 1 malocclusion on a Class II dental base. I did not myself see this case in these early stages, and can only say that at this stage there was an erupted central supernumerary tooth which was extracted (*Fig.* 2A).

In January, 1958, I acquired this patient and all four first premolars were removed. Subsequently, upper and lower round-wire arches were fitted after banding all the standing teeth. Class II elastics were fitted for inter-arch traction.

Fig. 3.—*Patient S. D.* Models from above downwards, showing initial condition, at the end of active treatment, one year after retention, and two years out of retention.

By the beginning of 1961 the upper fixed appliance was removed, and I am grateful to Mr. D. A. Plint for continuing treatment whilst I was abroad.

By August 1961 the lower arch was satisfactory (*Fig.* 2B) and the case was retained from January, 1962, to January, 1963 (*Fig.* 2C). The change which was noted on a lateral skull radiograph is shown in *Fig.* 2D.

Of course I am not claiming that a multibanded appliance is always necessary in both upper and lower arches. Indeed, in some of our most successful cases a combination of upper removable appliance therapy and lower fixed appliance therapy has produced excellent results. A particular situation in which this combination is likely to prove most effective is where a case is seen fairly late, in say, the 12–16-year-old age-group where lower first permanent molars have become so carious, heavily filled, or broken down that their long-term prognosis is poor, and where extractions are necessary in the lower arch to relieve lower incisor crowding. Sometimes, the upper first permanent molars can be conserved, and in the next case it was decided to extract the upper first premolars and the lower first molars. This boy (*S.D.*) was $11\frac{1}{2}$ years old when treatment was commenced, and so it would be unreasonable to hope for complete

forward movement of the lower second molars toward the second premolar without some form of appliance treatment. He had an indefinite Angle Class II malocclusion on a mild Class II dental base (*Fig.* 3). The lips were incompetent and habitually apart with a tooth-apart swallow. I was doubtful about an anterior tongue thrust. There was a definite tongue-to-lip resting posture. He wore an upper removable appliance with extra-oral traction and in January, 1962, a lower

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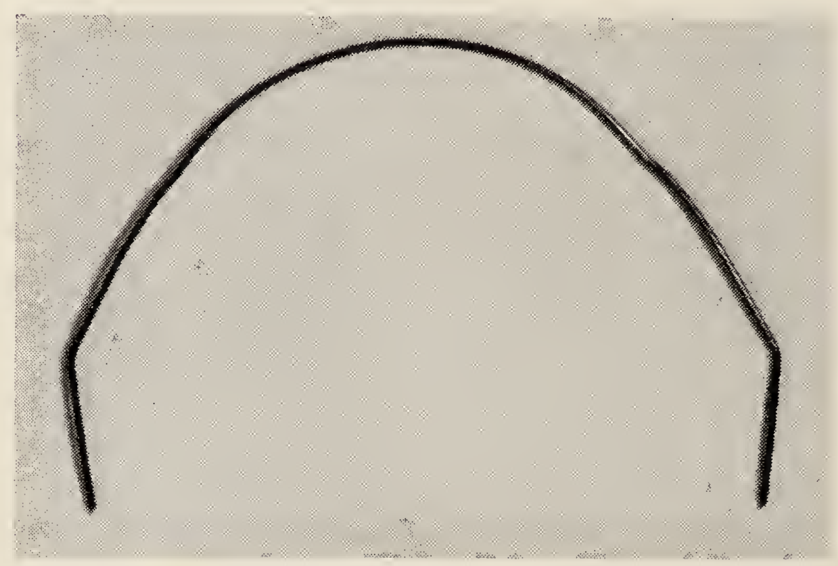

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Fig. 4.—A, Showing the degree of ' tip down ' at the distal end of the arch wire. B, Showing the degree of ' toe-in ' at the distal ends of the arch wire.

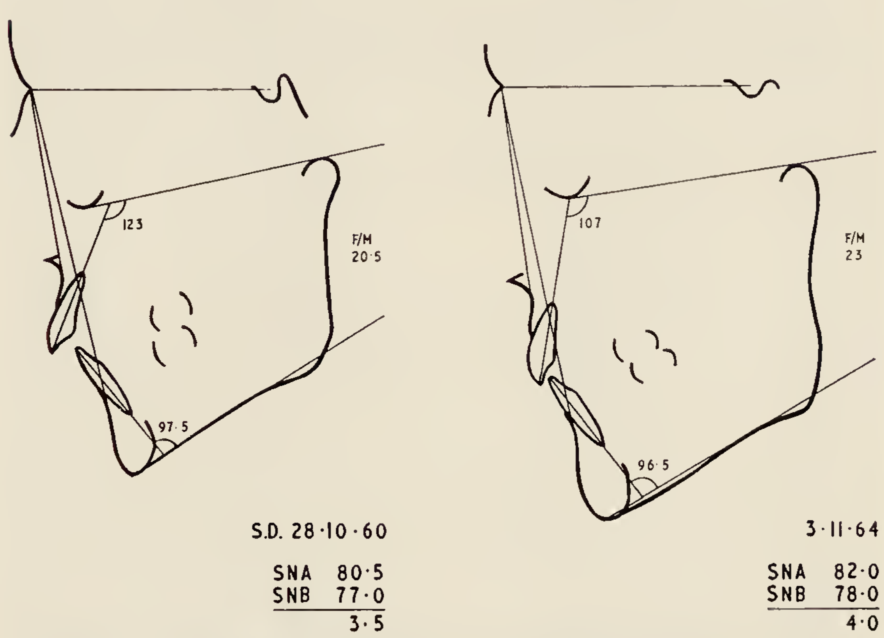


Fig. 5.—Showing before treatment and post-retention lateral skull radiograph tracings.

multibanded appliance was fitted with bands on all standing teeth. An alining arch in 0·016 in. was fitted, and Class II elastics attached to the upper removable appliance which was being used to retract the upper incisors. Upper incisor retraction proceeded satisfactorily, but residual space was left in the lower first molar region and treatment was revised so that intra-arch traction was used in the lower arch, having Bull loops to bring forward the lower second molars. It was found necessary to incorporate tip-down bends (*Fig.* 4A) to prevent the lower second molars from tipping forward and toe-in bends to reduce rolling (*Fig.* 4B). In fact, they did tip forward and had to be actively uprighted at a later stage. Active treatment was completed in December, 1962, and the case was retained for seven months (*Fig.* 3). The lateral skull radiographs are shown (*Fig.* 5).

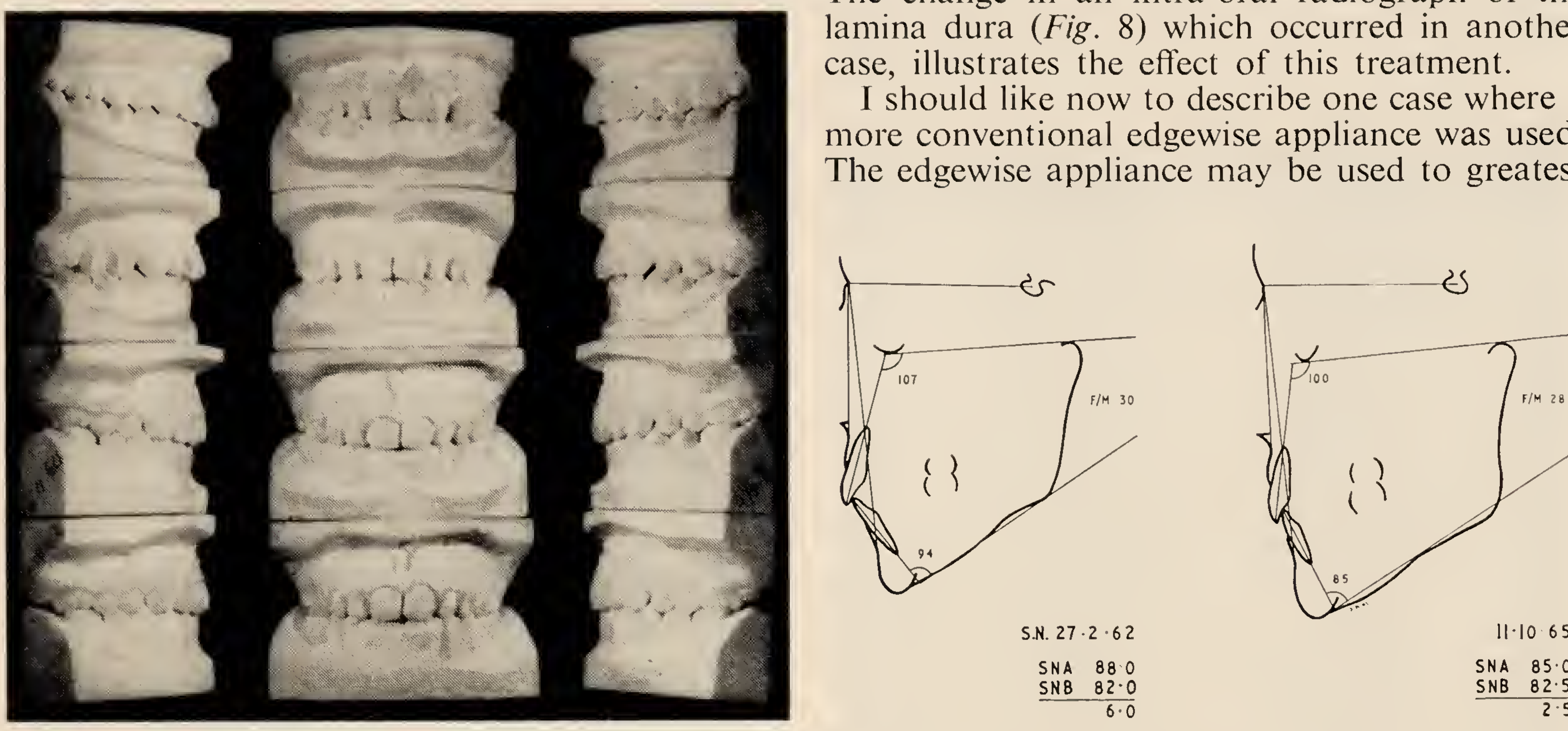
Bearing this case in mind the next one which I would like to describe presented similar problems. Here the patient, a girl (*S.N.*), born on 27.9.50, had an Angle Class I malocclusion on a Class I dental base (*Fig.* 6A). The soft-tissue morphology and behaviour were entirely normal. The first permanent molars had a poor prognosis because of caries.

It was decided to extract all four first permanent molars, retract the upper buccal segments with removable appliances, and utilize a lower multibanded appliance to close residual spaces.

By now I was becoming aware of the disadvantages of the round-wire multibanded appliance in closing first molar spaces and right from the beginning I fitted standard edgewise brackets on all the lower teeth and edgewise buccal tubes on the anchor molars, in this case the lower second permanent molars. For the first six months I used a round-wire arch in 0·0185 in. to produce the tooth movements which I required. These consisted in moving back the lower premolars by means of push coils tied back to the distal of the anchor molar with a soft-wire ligature. When the lower premolar, canine, and the incisor crowding had been relieved there was still residual spacing in the first molar region, and I decided to change my lower arch treatment so as to have a standard edgewise arch-wire 0·0215 in. $\times$0·028 in. with Bull loops so placed as to drag forward the lower second molars on activation. This was successful, and the molars were brought forward to the second premolars in eight months. The actual dates are 11.2.62 and 3.10.63. I did find on review three months later that the lower first molar spaces had opened up somewhat and these tended to persist for some while, but gradually closed up again without further treatment (*Fig.* 6A). A lateral skull tracing shows the changes (*Fig.* 6B).

I would like now to refer to my first case as it illustrates the particular point yet once more.

It will be recalled that the cross-bite in the premolar region was corrected with a lower



A B

Fig. 6.—*Patient S. N.* A, Showing, from above downwards, the case before treatment, at the end of active treatment, at the end of retention, and one year out of retention. B, Lateral skull tracings before treatment and one year out of retention.

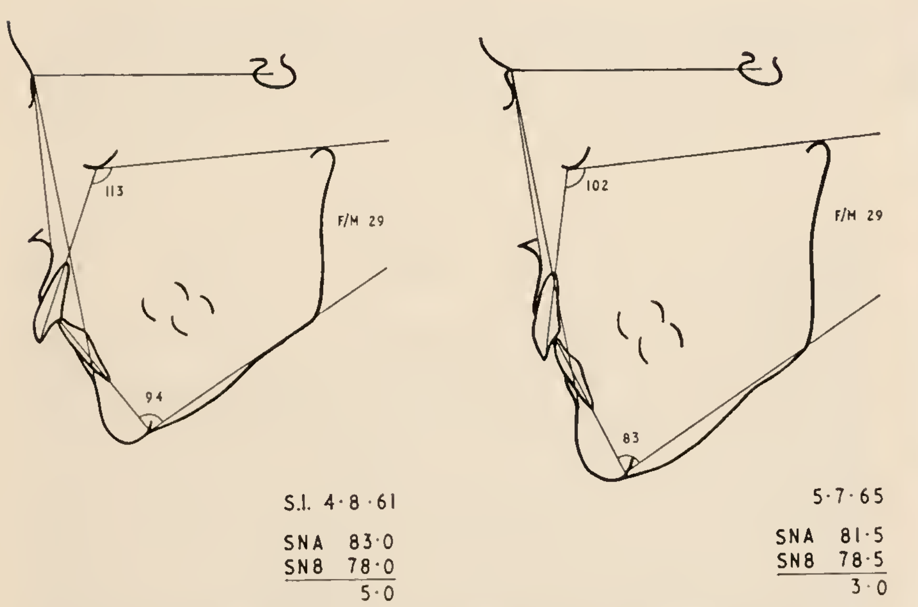


Fig. 7.—*Patient S. I.* Lateral skull tracings before treatment and one year out of retention.

lingual arch, having attached finger springs to correct the premolar 'cross-bite'. Treatment was completed with a full strap-up and a rectangular arch wire, 0·0215 in. × 0·027 in. to complete alinement and advance the lower left second molar. This was fitted in November, 1962, and removed on completion of tooth movement in January, 1964. During this time the case was treated with inter-arch traction to an upper removable appliance, and the changes that have occurred are seen on a lateral skull radiograph (*Fig.* 7).

I feel that this method of advancing the second molar is a most useful form of treatment, although I do not attach any particular name or philosophy of edgewise treatment to it. It is merely common-sense orthodontics using a square wire to achieve a specific end-result. The change in an intra-oral radiograph of the lamina dura (*Fig.* 8) which occurred in another case, illustrates the effect of this treatment.

I should like now to describe one case where a more conventional edgewise appliance was used. The edgewise appliance may be used to greatest advantage when treating an Angle Class II, division 2 type of malocclusion where ' control ' of upper incisor apices is indicated.

Fig. 8.—Radiograph of a lower first permanent molar which has been moved medially showing an enlarged lamina dura distal to each root.

This boy (*R.W.*), born on 16.2.48, presented with a rather aggressive Angle Class II, division 2 malocclusion on a Class II dental base (*Fig.* 9A). There was a severe double retroclination and the gingiva palatal to the upper incisors was being severely traumatized. The lips were competent and habitually together and the swallow was upper canines and remaining teeth in the buccal segments. I had found that I was getting too much friction in the buccal segments, with the result that at first the overjet was increasing and this had to be adjusted. It is most important to ensure that friction does not jeopardize incisor movements and a continual check must be kept on this point. By ' second order bends ' I mean tip-back bends used to tip teeth in the buccal segments in a distal direction. While this treatment in the upper arch was

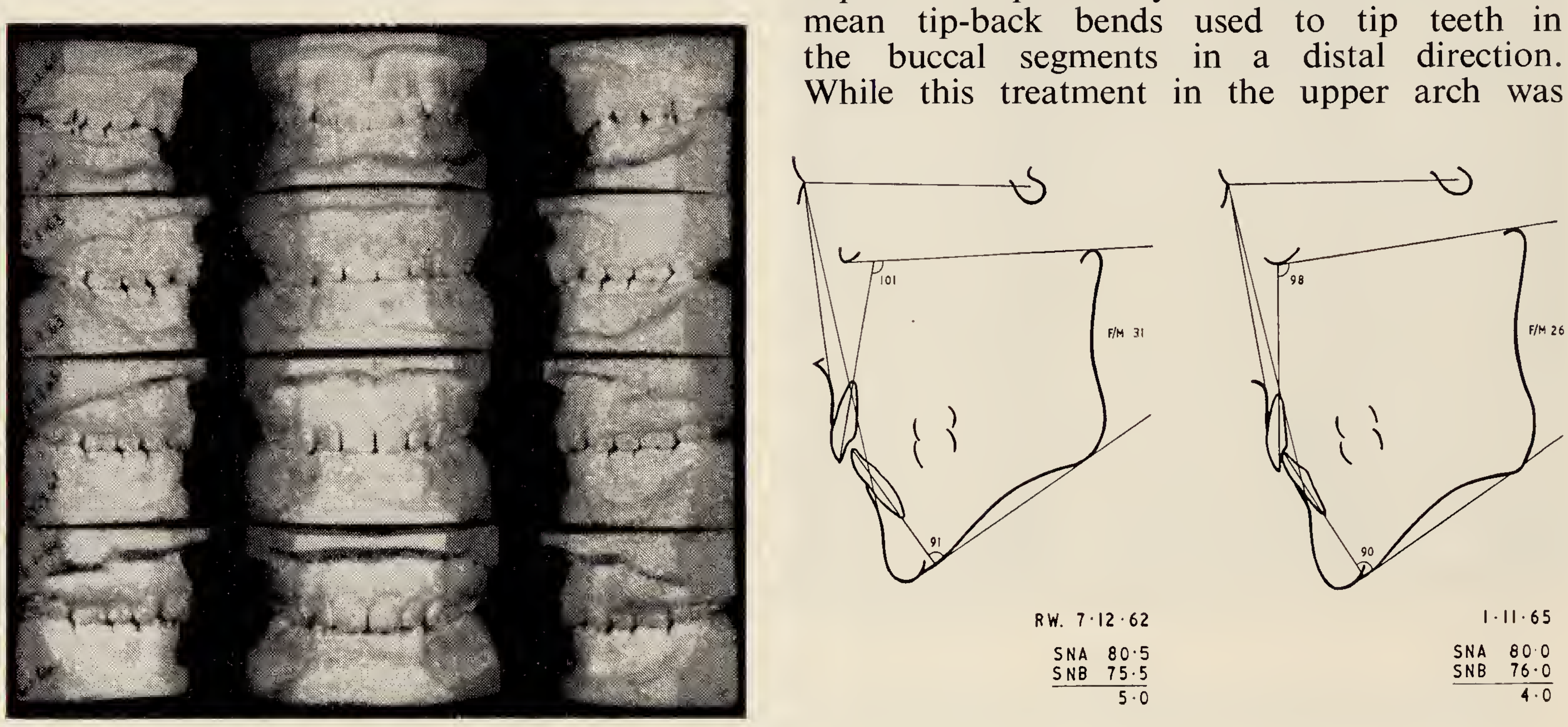


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Fig. 9.—*Patient R. W.* A, Showing from above downwards, models before treatment, at the end of treatment, at the end of retention, and just out of retention. Later models taken two years out of retention are not shown. B, Lateral skull tracings taken before edgewise treatment and two years out of retention.

tooth apart, but without any evidence of an anterior tongue thrust. There was a tendency towards overcrowding in both upper and lower arches.

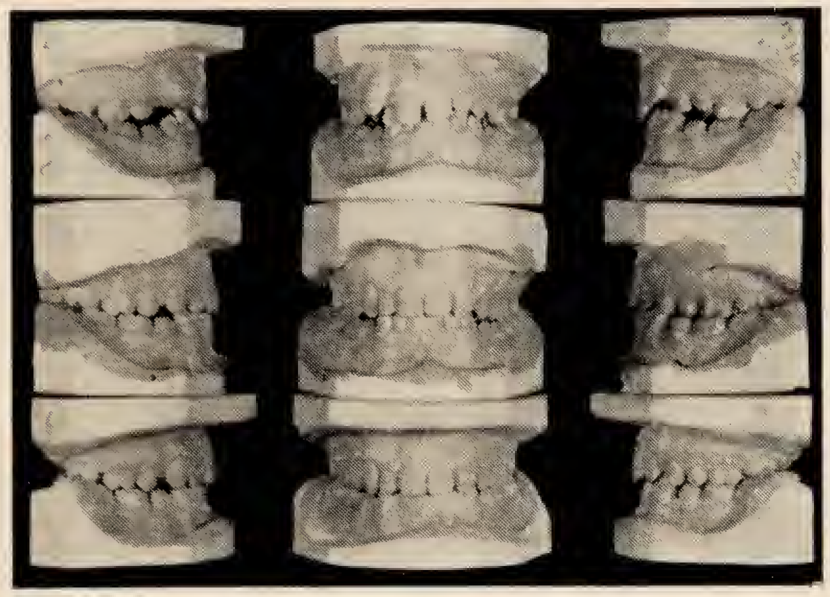
The extraction of all four first premolars was recommended and a lower round-wire multi-banded appliance was fitted by another member of our staff at the Royal Dental Hospital. An upper removable appliance was also fitted to commence the retraction of the canines. This appliance also incorporated extra-oral traction to head gear. When the canines had been retracted almost all the way it was realized that the time had come to correct the incisor relation with fixed appliances and so, as I had just returned from the United States, it was decided to allow me to attempt to carry on with treatment.

All teeth standing in the upper arch were banded and after using round-wire alining arches, in September, 1961, an 0·0215 in. × 0·027 in. arch was fitted with loops for inter-arch traction. Extra-oral anchorage was attached to this appliance. At first I used a cervical strap, but later replaced this with full head gear. By October, 1961, the upper incisors were moving back nicely and the arch wire incorporated palatal root torque and had second order bends on the progressing, lower arch treatment was continued, somewhat heretically, with a round-wire arch in 0·020 in.

The arch wire incorporated a reverse Curve of Spee in a further attempt to discourage forward movement of the anchor teeth. By the beginning of January, 1962, it was decided that the incisor retraction could be completed using Bull loops under tension, and by this means the upper incisors were taken fully back to reduce the overjet and aline the upper incisors correctly. This treatment was completed by May, 1962, that is five months later, and final incisor torques were completed by the use of so-called 'artistic' bends in June, 1962. By August, 1962, there was still a small space left between the upper central incisors and a median closing loop was incorporated in a fresh arch. This had achieved its objective by December, 1962, and the upper arch was retained for three months with the fixed appliance. This was removed and replaced with a removable retainer in March, 1963, which the patient wore continuously for three months and at night only for a further period of three months. I would emphasize that I only employed retention for a total of six months altogether. This patient has been seen at regular intervals since

then, and as will be seen from the most recent set of models the occlusion is quite satisfactory (*Fig.* 9A). I am not entirely satisfied with the alinement in the lower arch and feel that I should have used an edgewise arch in the lower instead of persevering with the round wire. The figure shows a comparison of before treatment and two years out of retention lateral skull tracings (*Fig.* 9B).

A criticism which is often levelled at proponents of fixed appliance therapy is that when one is dealing with large numbers of cases it is impracticable. I have found in my own experience, working as a Regional Hospital Consultant, that the indication for fixed appliances though small, is still real and has to be met. I feel it is worthwhile spending longer on a particular patient fitting a fixed appliance if in so doing one can achieve a more rapid result. The following case illustrates my meaning exactly. This girl (*S.L.*) presented with an Angle Class I malocclusion on a Class I dental base (*Fig.* 10A). The soft-tissue morphology and behaviour were normal. Both lower first premolars and the upper right first premolar and upper left lateral incisor had already been removed when I first saw her. I delayed commencing treatment for twelve months to allow further eruption of the upper left canine.



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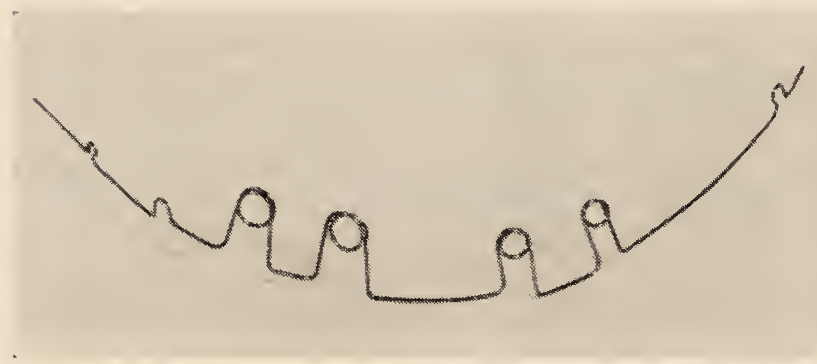

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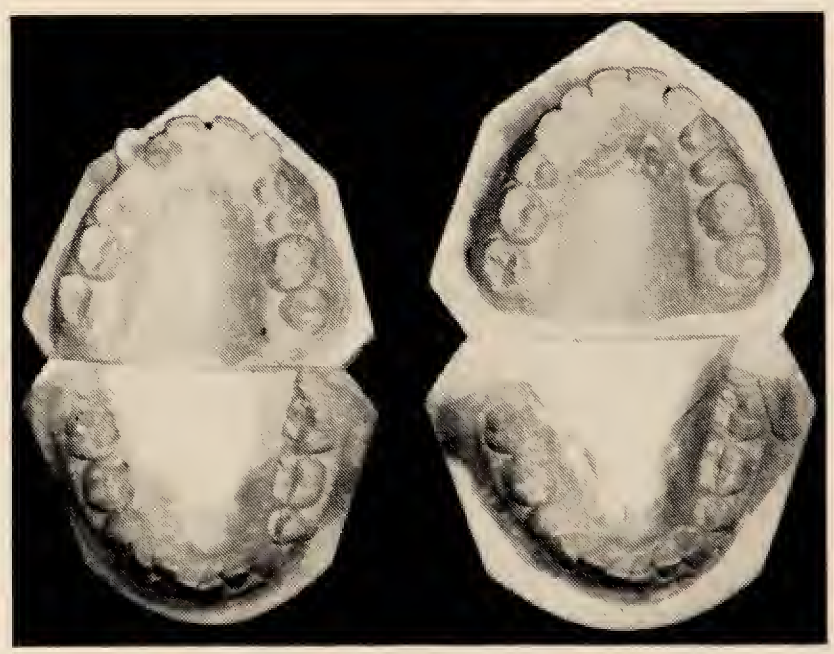

C

Fig. 10.—*Patient S. L.* A, Models from above downwards, showing case before treatment, at the end of active treatment, and during retention. B, Vertical loop arch used in treatment of *S. L.* C, Occlusal view of models before treatment and during retention.

I decided to treat the case with a multiple loop type of appliance similar to that described by Jarabak and Fizzell (1963), and banded all the upper teeth, fitting standard edgewise brackets and standard edgewise buccal tubes where necessary. This was done in January, 1965. I fitted a vertical loop arch in 0·018 in. high tensile wire (*Fig.* 10B). This arch was also used to move back the upper canines by compressing the loops against the medial of the canine brackets. At the same time it dragged them down towards a normal position in the occlusal plane. This arch was followed by a further arch in 0·020 in. having Bull loops which were activated to close residual space. A final alining arch in 0·022 in. × 0·017 in. was fitted in August, 1965, and treatment was completed within ten months. The patient is now wearing a removable retention appliance. I am not claiming too much for this case as the ultimate test is stability after retention is withdrawn. The figure shows before and after models (*Fig.* 10A, C), but I regret that I have no lateral skull radiographs to show you.

I have not outlined the indications for or described the Johnson twin-wire appliance neither the pin and tube appliance as I feel that these have been very adequately described elsewhere by Mills (1959) and Watkin (1933).

SUMMARY

In conclusion I have attempted to show how different fixed appliances may be indicated in treatment and in so doing would emphasize how important it is not to develop a ‘ one philosophy ’ attitude.

I feel that where complicated tooth movements are required it is best to fit edgewise brackets and tubes from the beginning. What is not generally realized is that while most of the necessary tooth movements can be achieved with round

wire arches, final alinement with a rectangular wire is quick, certain, and reliable.

Acknowledgements

I should like to record my very great indebtedness to the British Postgraduate Medical Federation and the Royal Dental Hospital for making my tour of the United States possible and to Professor D. P. Walther for his generous encouragement and support. I should also like to thank him and Mr. John Hovell for allowing me to publish details of cases under their care at the Royal Dental Hospital of London. I should like to thank the Photographic Departments and Orthodontic Laboratories of the Royal Dental Hospital, London, and the Coventry and Warwickshire Hospital, Coventry, for their assistance in preparing material for, and the taking of, photographs.

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DISCUSSION

Mr. C. D. Parker, opening the discussion, referred to Mr. Briggs' introductory remark about socio-economic conditions; these, as they all knew, constantly changed. Mr. Parker said he would think it very likely that fixed appliances would be used more frequently in the future and were well worthy of their continuing interest. He hoped that, as more dentists became experienced in these techniques, these appliances would be used more discerningly.

Mr. Briggs had stated that apical movement, using round arch wire, was difficult or even impossible. This Mr. Parker said he was unable to accept, either from his own experience or on theoretical grounds. Although theoretically the idea of using rectangular arch wire fitting into a rectangular bracket gave all the possibilities of moving either the crowns or the roots of teeth in any required direction, it suffered certain practical disadvantages.

The first of these was that such a close fitting arch wire produced a great deal of friction which, in turn, could easily lead to disruption of anchorage and difficulty in estimating the response of teeth used as an anchorage. The second point was that using this relatively thick rectangular wire resulted in relatively small distortions of the arch wire applying heavy force to the teeth. The other main criticism was that many rectangular arch wire techniques were over-elaborate and resulted in unnecessary tooth movements being carried out.

Having been deliberately provocative, he would like to ask if, in the fourth case, where the four first molars had been removed, was the opening up of the lower first molar space when the rectangular arch was removed, evidence that the anterior block of teeth had been moved lingually into an unstable position during the period in which the rectangular arch wire was worn?

Mr. C. P. Briggs, in reply, agreed with Mr. Parker that with certain very advanced techniques with the round-wire arch, apical movement of the incisor was impossible. One disadvantage of the rectangular arch wire was friction. He occasionally used electrolytic reduction in the buccal segments of the arch wire to reduce this if necessary. He thought it was true that with the heavy rectangular arch wire the forces were large, but they only acted over a short period of time. He had not had a patient complain of pain from the forces used. Regarding the case where the lower first molar space opened up, he thought what had probably happened was that the tooth had been tilted forward during movement and then uprighted itself when the appliances were withdrawn. He said he would have to study his lateral skull tracings more fully before saying whether there was lingual movement of the lower incisors.

The President (*Mr. R. E. Rix*) felt it a pity they were forsaking the decimal system and giving these measurements of arch wires in fractions of inches.

He had only one question; in regard to those cases in America where, left to his own resources, Mr. Briggs might have taken out some teeth in the first instance, had he formed any opinion as to the fate of the third molar in those cases?

Mr. C. P. Briggs agreed it would be much more preferable to use the decimal system.

In reply to Mr. Rix's question he thought the American orthodontist would reply that the position of the third permanent molar was not his responsibility as he would refer the case to an oral surgeon.

Mr. J. R. Pettman said that he had encountered difficulties in the closing of spaces left after the extraction of lower first permanent molars. When he had been successful, he had found that success depended to a great extent on the initial crowding, especially on the crowding he would expect to come from second and third molars.

Also, he had encountered a lot of obstruction from the upper teeth when closing large lower spaces. Hard food had rammed into and distorted the Bull loop area.

Mr. C. P. Briggs said he would agree that if the arch was particularly crowded space closure was easier. It was a question of how crowded the case was when one started.

His own way to prevent distortion of the Bull loop was by using an upper removable appliance which would have an anterior inclined or flat biting plane.

Mr. E. K. Breakspear said he had been particularly interested in the case with the supernumerary, where the central had beenrotated. Was it over-rotated in that case? If not, could Mr. Briggs comment on its apparent stability?

Mr. C. P. Briggs said the reply was no, it was not over-rotated. He thought it was stable because in effect it was in retention for such a long period whilst he was treating the case.

Mr. P. R. W. Coyle asked if Mr. Briggs used off-set or bayonet bends in the lower incisor region to over-correct misalinements.

Mr. C. P. Briggs said sometimes he used bayonet bends, sometimes not. What was important was to incorporate bayonet bends mesial to the lower second premolar if one retracted the lower canine. If one retracted the lower canine into the first premolar space so that its buccal aspect was in the same position as the premolar buccal aspect had been, one tended to get intercanine collapse afterwards.

Mr. M. L. Brenchley agreed that the tipping of lower second molars was difficult, but he felt it was important to get them under control by encouraging them to upright distally, not turning down the distal end of the arch wire, before attempting to bring them forward.

Mr. G. H. Steel said that looking back on the final models which Mr. Briggs had shown, there appears to be a high incidence of crowded lower incisors. He wondered if Mr. Briggs regretted having not extracted more lower first premolars.

Mr. C. P. Briggs said that in the cases he had shown the lower first molars had had to be removed because of caries. He would have preferred lower first premolars.

Mr. D. G. Huggins asked in what percentage of the cases did Mr. Briggs use fixed appliances.

Mr. C. P. Briggs said that generally speaking, he devoted one session a week out of nine sessions, so it would be in the region of one-ninth.

AN ASSESSMENT OF CLASS III MALOCCLUSION

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THE original purpose of this paper was to assess, as part of a larger study, the changes which took place in the upper and lower incisor positions as a result of orthodontic treatment of cases of Class III malocclusion. During the investigation other factors emerged so that the paper is now a study of changes taking place during treatment, with some observations on the nature of the original condition.

For the purpose of this study, Class III malocclusion is considered to exist in any patient having at least three upper incisors occluding lingually to the corresponding lower incisors. This is different from Angle's definition, which was based on molar relationship, but it is felt that the group so defined is a natural one. The sample consisted of forty-four patients treated at the Eastman Dental Hospital. All had full records including a final lateral skull radiograph taken at least twelve months after appliances (including any retention appliance) were discarded. It may be that some severe cases were considered to be untreatable by non-surgical means, and were thus excluded from the sample. Otherwise it was unselected. Details of this sample are given in *Table I*. The average age at the beginning of treatment was 12 years, and at final examination 18 years; the age range was quite wide, and approximately half the children were in the mixed dentition at the beginning of treatment. None was in the complete deciduous dentition. A control group was necessary for comparison, and ideally this should be a similar group of Class III malocclusions which had not received orthodontic treatment. This is clearly impossible on ethical grounds. A sample of twenty-four untreated London schoolchildren was available for whom radiographs had been taken at a mean age of 13 years 10 months and again at a mean age of 19 years. None of these children had received orthodontic treatment, and the children were not selected in any way—all types of occlusion were represented. Although the age range did not coincide exactly with that

Table I.—CONSTITUTION OF THE EXPERIMENTAL AND CONTROL GROUPS

	EXPERIMENTAL GROUP	CONTROL GROUP
Number in group	44	24
Mean age, first X-ray	12 yr. 2 mth.	13 yr. 10 mth.
Range of ages, first X-ray	7 yr. 1 mth./29 yr. 3 mth.	13 yr. 3 mth./14 yr. 10 mth.
Mean age, final X-ray	18 yr. 2 mth.	18 yr. 11 mth.
Range of ages, final X-ray	10 yr. 3 mth./31 yr. 11 mth.	17 yr. 7 mth./20 yr. 1 mth.
Mean observation period	5 yr. 11 mth.	5 yr. 1 mth.
Range of observation (periods)	1 yr. 3 mth./11 yr. 3 mth.	4 yr. 4 mth./5 yr. 10 mth.
Mean time out of retention	3 yr. 1 mth.	—
Range of times out of retention	1 yr./9 yr. 1 mth.	—

Presented at the meeting of the B.S.S.O. held on 18 April, 1966.

of the experimental group it was considered preferable to use it as a group rather than risk the errors of extrapolation.

We were thus able to assess the changes in the Class III group some years after treatment. I felt it would be interesting to compare these long-term changes with those seen immediately after the mean period covered by this short-term investigation was 1 year 3 months, compared with 5 years 11 months for the long-term study.

The radiographs were traced by Miss G. T. D. Pickard in the conventional manner. The accuracy has been checked by double determination and the results given in a previous paper by

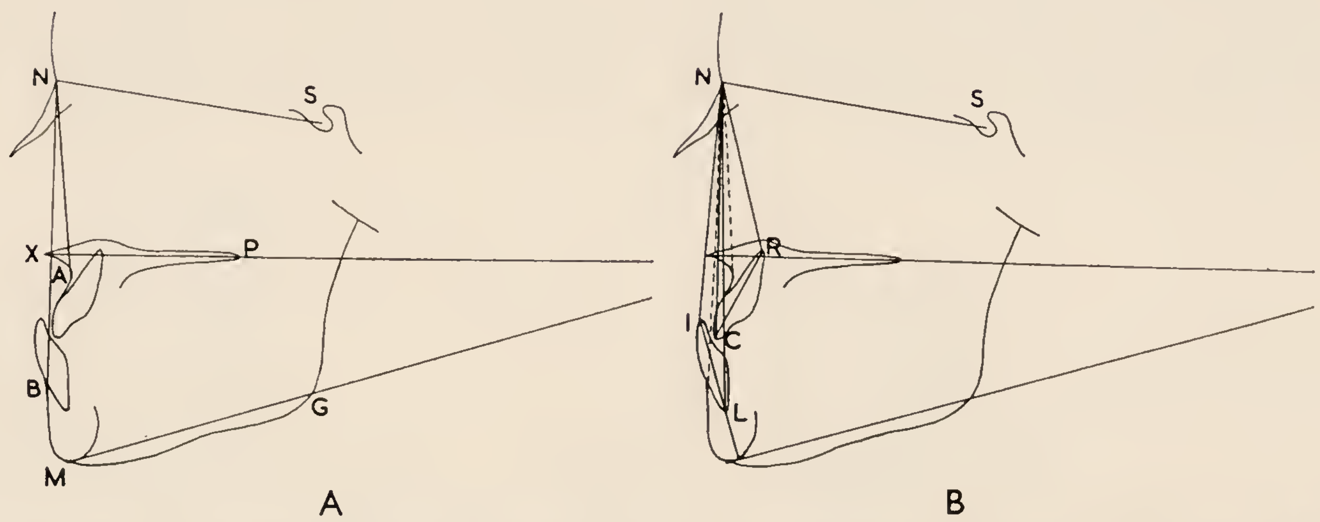


Fig. 1.—Showing the points used in the investigation. A, Skeletal assessment. B, Assessment of incisal positions.

Table II.—Assessment of Skeletal Pattern

	Experimental Group		Control Group		Significance	
Conditions in first radiograph	*Mean*	*S.D.*	*Mean*	*S.D.*	*t*	*P*
SNA	78·85	3·22	81·06	2·87	2·869	0·01**
SNB	80·70	3·15	78·03	3·26	3·404	0·01**
ANB	− 1·77	2·59	3·35	2·29	8·44	0·001***
M/M Angle	27·28	5·45	26·71	4·08	0·458	0·70
Facial percentage	54·36	2·08	54·60	2·18	0·458	0·70
Short-term changes						
SNA	+ 0·33	0·72				
SNB	− 0·44	1·03				
ANB	+ 0·87	1·07				
M/M Angle	+ 0·53	1·51				
Facial percentage	+ 0·55	0·81				
Long-term changes						
SNA	+ 0·60	1·32	0·0	1·11	1·944	0·10
SNB	+ 0·42	1·46	+ 0·60	1·39	0·560	0·70
ANB	+ 0·16	1·20	− 0·54	0·94	2·542	0·02*
M/M Angle	− 1·14	2·89	− 0·48	1·73	1·056	0·30
Facial percentage	+ 0·95	1·50	+ 0·59	0·97	1·085	0·30

* Just significant; 5 per cent level.
** Significant; 1 per cent level.
*** Highly significant; 0·1 per cent level.

incisor relationship had been corrected. I therefore calculated the change occurring for each patient between the last radiograph which showed the upper incisors lingual to the lowers and the first to exhibit the corrected incisor relationship. Adequate records were not available for five cases, which were therefore discarded for this part of the investigation. The us (Mills, 1966). In addition to standard cephalometric points (*Fig.* 1 A), the outlines of the most prominent upper and lower incisors were traced, and a line drawn along their long axis (*Fig.* 1 B). The point where this intersected the incisal edge was called C in the upper and I in the lower arch, while the point where this line cut the root apex was called R and L respectively.

The measurements made will be described in the relevant sections of the paper.

RESULTS

Skeletal Pattern

Anteroposterior Relations

The relationships of the apical bases to each other in the experimental and control groups were assessed in the anteroposterior and vertical planes. The anteroposterior relationship was assessed by means of the angles SNA and SNB and their difference, ANB (*Table II*).

The mean value for SNA, before treatment, was significantly lower than in the control group, while that for SNB was significantly higher. This confirms findings of numerous authors, notably Bjork (1947), Maj, Luzi, and Lucchese (1958), Hopkin (1962), Freunthaller (1964), and Joffe (1965), to the effect that a Class III incisor relationship may be due to a posterior position of the upper apical base, an anterior position of the lower base, or a combination of the two. The angle ANB was very significantly different in the two groups. In the overwhelming majority of prenormal occlusions there was a Class III skeletal pattern, again corroborating the findings of the above authors. *Fig.* 2 is a histogram formed from the individual initial values of the angle ANB for the experimental group (above the horizontal ordinate) and the control group (below the line). It will be seen that in only two individuals of the experimental group does the value for ANB lie within one standard deviation of the mean for the control group. Both these girls were Jewish, with a rather typical bimaxillary proclination, and it is, perhaps, unfair to compare them with an essentially non-Jewish control group. It would seem that an abnormal skeletal pattern is overwhelmingly important in the aetiology of this condition.

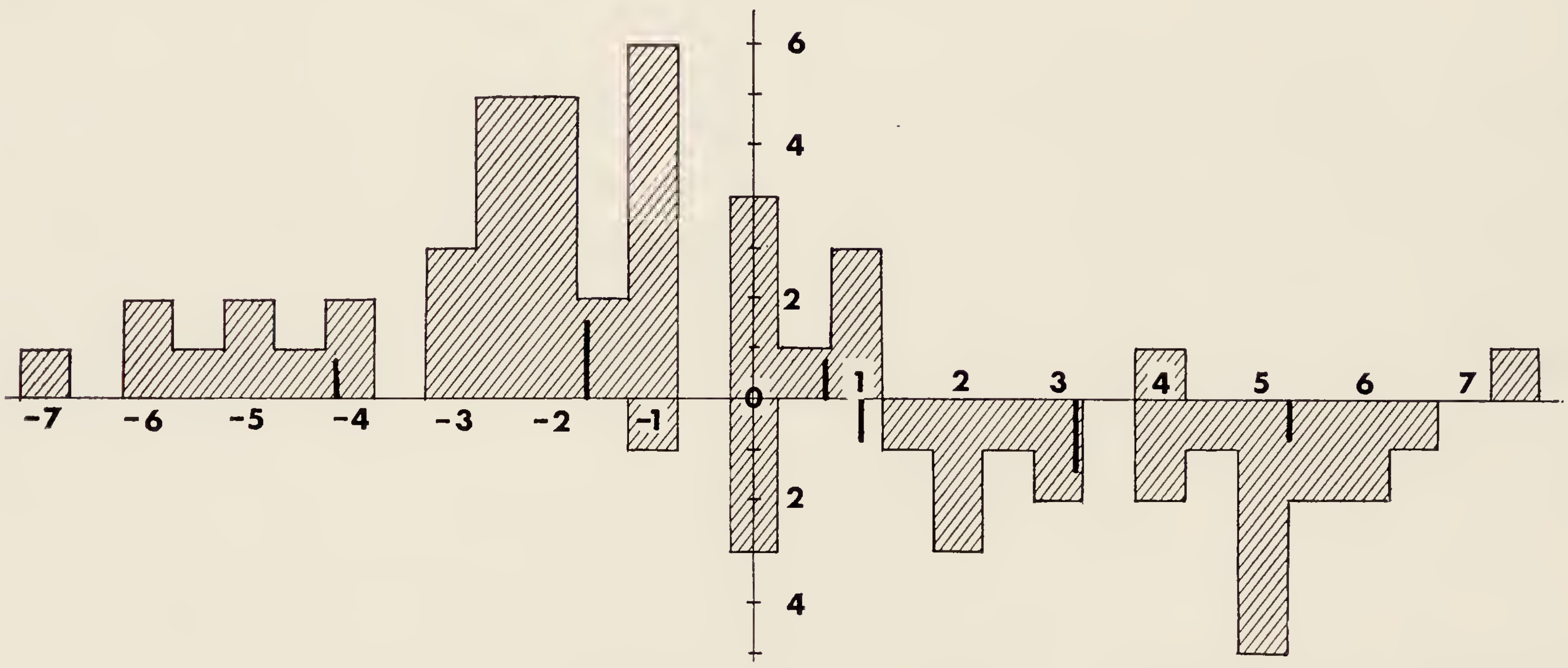


Fig. 2.—Histogram to show the angle ANB in the first radiograph, shown in degrees on the horizontal ordinate, above the line in the experimental group, below the line in the control group. The thick lines show the means and one standard deviation width.

It has often been claimed that treatment of Class III malocclusion produces a change in the skeletal pattern. In previous cephalometric investigations a small change has been found in the ANB angle, indicating a posterior displacement of point B relative to point A. This has been reported by Hopkin (1962) and Rakosi (1963), while Freunthaller (1964) has reported a forward movement of point A only. My own findings show a difference in the long term between the experimental and control groups of about 0·7° in the change in the angle ANB, which is essentially similar to other investigators, and which is just significant. While this is clinically negligible, it seems sufficiently interesting to warrant further investigation. *Fig.* 3 is a histogram of the changes in the angle ANB in the two groups. It will be seen that the changes in the control group do not form a normal curve; there are few values above the model value of zero. Where any change does take place, it is likely to be a decrease. The shape of the histogram for the experimental group is essentially similar except that there are a number of individuals in whom the angle ANB increases. In other words, the difference between the two groups was not due to an overall difference, but resulted from a few cases which seemed to behave differently. These were investigated individually and it appeared that in some cases there was an undue increase in the angle SNA, in others an actual decrease in SNB, and in only one case both. The effect of these few cases was not sufficient to make the changes in angles SNA and SNB significantly different in the two

groups, although the former approached significance.

In those cases in which there was an unexpected increase in SNA it would seem that this was associated with exceptional proclination of the upper incisors, and consequent remodelling of the alveolus, as shown in *Fig.* 4. If the alveolus

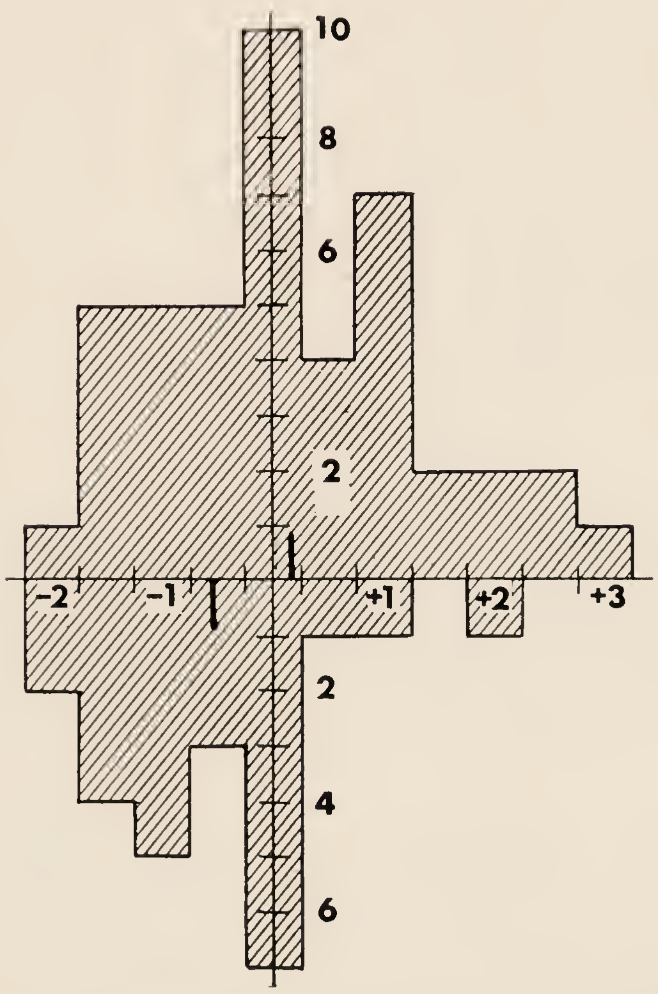


Fig. 3.—Histogram to show the long-term changes in the angle ANB in the two groups. The experimental group above the line and control group below. Changes are in degrees on the horizontal ordinate.

did not reform in the more anterior position, the incisor would have moved through the labial plate of bone.

The angle SNB showed a mean decrease in the short term, similar to that reported by Braccesi and Lucchese (1958), Freunthaller (1964), and Rakosi (1963), but in the long term the change in SNB was only slightly less than in the control group. In a few cases the angle actually decreased in the long term, probably due to the elimination of a true forward displacement of the mandible on closing.

Hopper (1955) and Ballard (1955) have both examined the type of Class III case in which the patient is able to achieve an edge-to-edge incisor relation, with the posterior teeth apart, but displaces the mandible forwards to bring the posterior teeth into occlusion. They have suggested that in this type of case the condyle returns to the centric position when the cheek teeth are in occlusion. This is certainly the case in the patient illustrated in *Fig.* 5 A, where the lower incisors are naturally retroclined. The radiograph has been traced with the teeth in occlusion, as shown by the solid line. The outline of the mandible was then rotated about a point in the centre of the condyle, until the upper incisors came to occupy the position shown by the dotted outline, in edge-to-edge relation with the lower teeth. This was the position achieved in life; in the diagram, however, the lower incisors passed ' through ' the uppers in moving from the occlusal to the edge-to-edge position, by pure rotation. In life a forward disengaging movement would be necessary. On the other hand, *Figs.* 5 B, C show the tracings of another

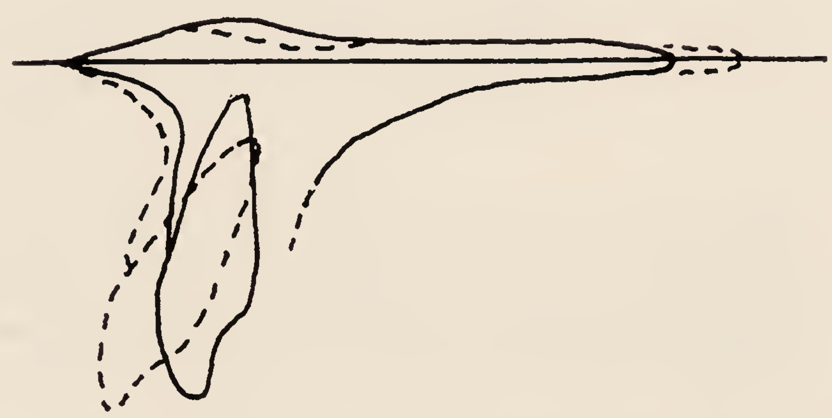


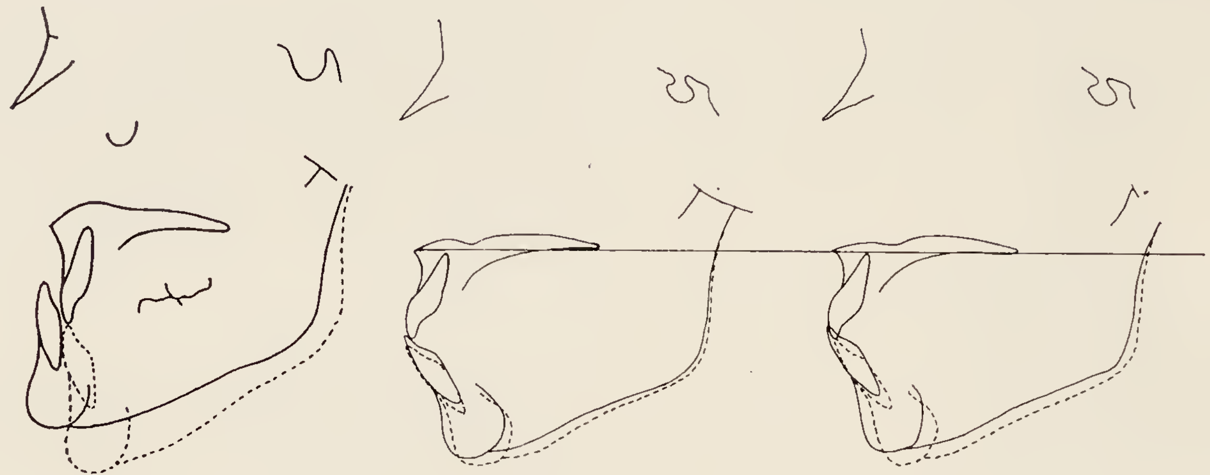
Fig. 4.—Maxillary outline and upper incisor of one case to show the remodelling of the labial alveolus following upper incisor proclination. (This is an extreme example.)

patient in whom the lower incisors were naturally proclined. In *Fig.* 5 B the solid outline shows the teeth in occlusion. The mandibular outline was again rotated about a point in the centre of the condyle to produce the dotted outline. This latter still shows some mandibular overjet, although the patient could, in fact, achieve an edge-to-edge relation without difficulty. *Fig.* 5 C shows the same case, but the broken outline has been displaced posteriorly so as to bring the incisors edge-to-edge. The solid outline shows the result of rotating the mandible about the centre of the condyle; clearly an impossible position. In this and a few other cases, a true anterior displacement of the condylar head is apparently present in closing. Elimination of this following treatment accounts for the slight posterior displacement of the point B during long-term observation. In the short term this is accentuated by a further decrease in SNB in cases where the maxillo-mandibular angle increases as a result of bite-opening (*see below*).

The combined mean effects of the forward remodelling of point A and backwards displacement of point B is just sufficient to make the difference in the changes in the angle ANB between the two groups significant, at the 5 per cent level. Although statistically significant, the actual amount is of no clinical importance.

Vertical Relations

The vertical relationship between the anterior parts of upper and lower jaws was assessed by two methods. Firstly, by means of the maxillo-mandibular planes angle (angle XP/MG in *Fig.* 1 A). This has the merit of being a widely used and easily measured angle, but the disadvantage that it is affected by changes both in the anterior region and in the region of the angle. It is, therefore, not wholly reliable in assessing anterior facial height. The second measurement was linear (*Fig.* 6). A perpendicular was drawn from nasion to the maxillary plane, and a similar perpendicular from the lowest point on the bony symphysis to the same plane. The length of each was measured, to the nearest millimetre, and the latter measurement expressed as a percentage of the combined heights, thus representing the proportion of the total facial height occupied by the intermaxillary space. For brevity this will be called the ' facial percentage ' in this paper.



A B C

Fig. 5.—A, The solid outline shows a patient in the occlusal position. The broken outline shows the mandible rotated about a point in the centre of the condyle. The edge-to-edge relation so achieved could be produced in life. B, In this patient, when the mandible was similarly rotated, some reverse overjet remains, although in fact the patient could achieve edge-to-edge relation. C, The case shown in B. In the broken outline the mandible has been displaced backwards to an edge-to-edge position. If rotated about the centre of the condyle, we get the impossible position shown by solid outline. A true displacement was present.

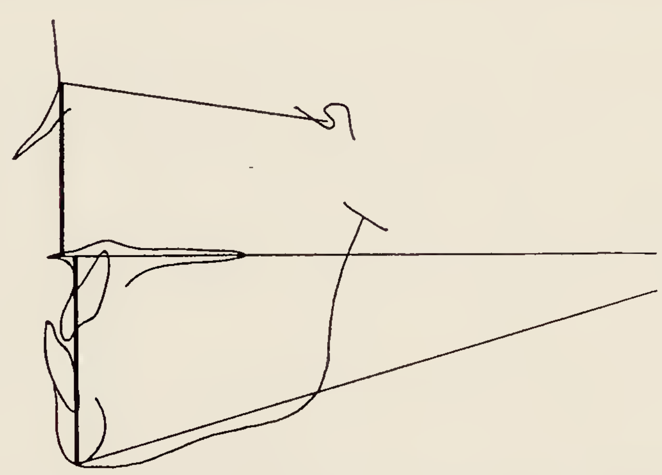


Fig. 6.—The thick lines show the distances measured in assessing upper and lower facial height.

It will be seen from *Table II* that the mean values for both measurements are almost identical in experimental and control groups. This is interesting for two reasons. McCallin (1955) describes Class III malocclusion by means of two extremes; one with an abnormally high and the other with an abnormally low gonial angle. Although he states that the distribution of vertical dimension is probably regular between the two extremes, he advocates division of Class III malocclusion into the two ' types ' when planning treatment. Walther (1960) also divides Class III malocclusion into these two ' types ', with the addition of a third—' pseudo-Class III ' —in which a Class III incisor relation occurs with a Class I skeletal pattern. This third type must be excessively rare (*see above*).

The second point of interest in the lower facial height concerns the statement by McCallin that ' overclosure ' is ' not uncommon ' in those Class III cases which exhibit a low gonial angle. This overclosure assumes that the mandible is closer to the maxilla than it would normally be, as a result of hyperactivity of the elevators of the mandible. A belief in the existence of overclosure in association with Class III malocclusion is widespread and is mentioned in most current textbooks, as well as in articles by Parker (1959) and Brenchley (1966).

It will be seen from *Table II* that the mean values of both maxillomandibular planes angle and facial percentage are almost identical for the two groups. *Fig.* 7 is a histogram for the maxillo-mandibular planes angle; above the horizontal ordinate are the values for the experimental group, while below this line are corresponding values for an unselected group of thirty-nine London schoolchildren aged between 13 and 14 years. It will be seen that this angle is reasonably evenly distributed around the mean value—there is a slight suggestion of ' skewness ' but this is also present in the control group. The

standard deviation is somewhat larger in the experimental group (*Table II*) although this is not true of the facial percentages. It would seem, therefore, that the lower facial height in Class III cases is similar to that in the general population, with possibly a tendency to include more extreme values. Cases which exhibit very high or very low values pose special clinical problems, but they are uncommon. The amount of incisor overbite is an important diagnostic point, but it is unrealistic to divide cases into two groups when the mean value is so close to the mode, and there is no suggestion of ' bimodalism '.

These findings also cast some doubt on the widespread presence of overclosure in Class III malocclusion. This was unexpected, and it was therefore decided to investigate the matter further. It is usually accepted that this overclosure is eliminated when the incisor relation has been corrected. The changes following treatment are shown in *Table II*. The short-term results show an increase in the maxillomandibular angle and a disproportionate increase in facial percentage. Similar results are reported by Hopkin (1962), Braccesi and Lucchese (1958), and Freunthaller (1964), while a very slight increase is reported by Rakosi (1963). It is not clear how long these authors' cases were followed after the end of treatment, but Hopkin finds considerably less increase of the mandibular angle on ' follow-up ' than he does immediately after orthodontic treatment. This increase in lower facial height immediately after orthodontic treatment is a common finding in all types of malocclusion, especially where the overbite has been reduced (*see*, especially, Parker, 1964). In my long-term results, however, the maxillo-mandibular angle actually decreases slightly more in the experimental than in the control group, although the facial proportion increases

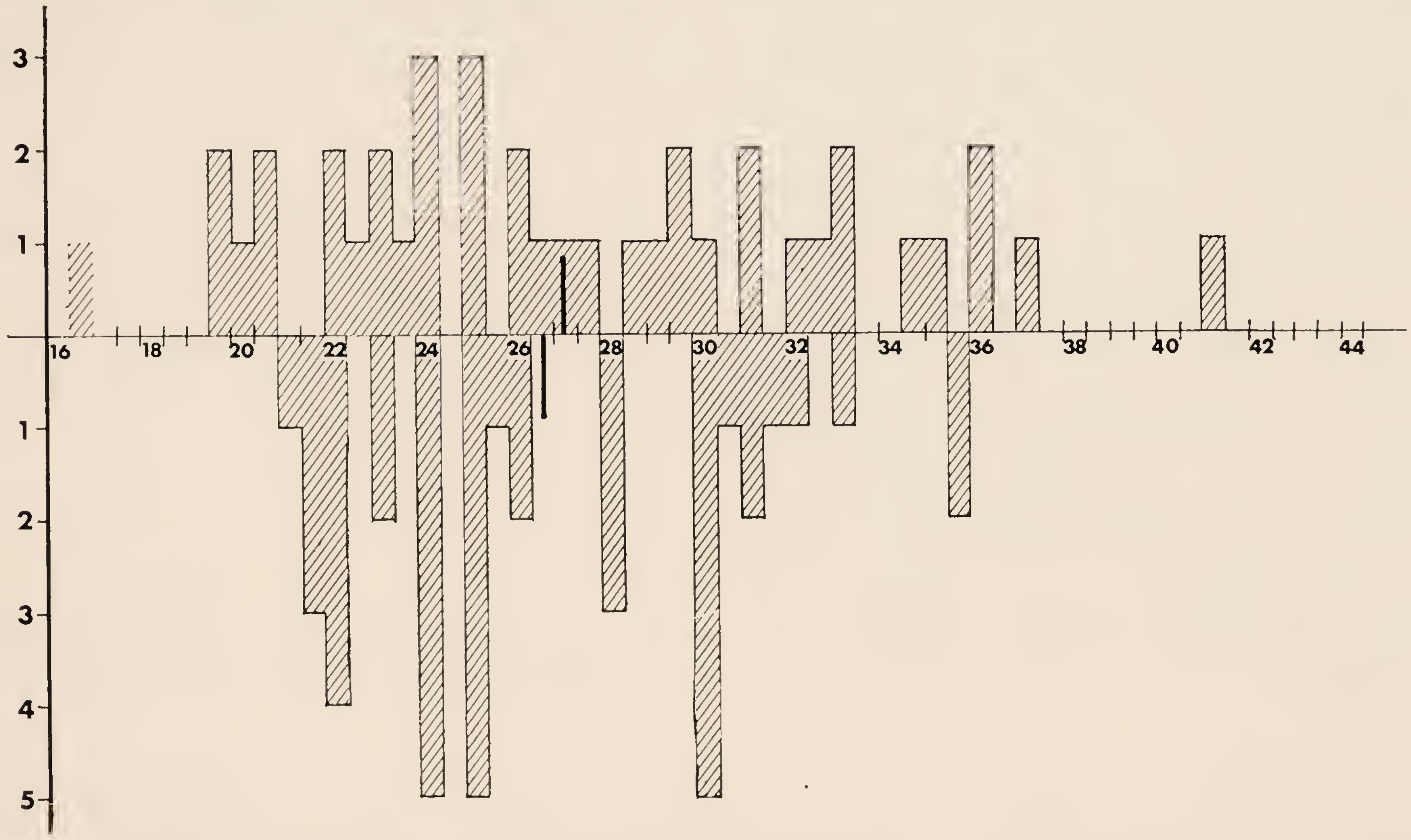


Fig. 7.—Histogram showing the maxillomandibular angles before treatment (above the line) compared with a random group of thirty-nine children of similar age. The thick lines show the mean values.

Table III.—Comparison of Changes in Vertical Relationship of Jaws during and after Treatment in Cases with Deep and Shallow Overbite

	Deep Overbite		Shallow Overbite		Significance	
	M	*S.D.*	*M*	*S.D.*	*t*	*P*
M/M Angle	−1·16	2·76	−0·97	2·40	0·220	7·90
Facial percentage	1·41	1·80	0·53	1·29	1·695	0·10

slightly more in the experimental group; neither difference is even remotely significant. This would seem to suggest that elimination of overclosure in the treatment of Class III malocclusion is not widespread, although it does not eliminate the possibility of its occurring occasionally.

If overclosure does occur, it would seem most likely among those cases which had a deep overbite, a low maxillomandibular angle, or both. I next divided my sample into three groups. Those in whom the upper incisors overlapped one-third or less of the lower incisor were regarded as

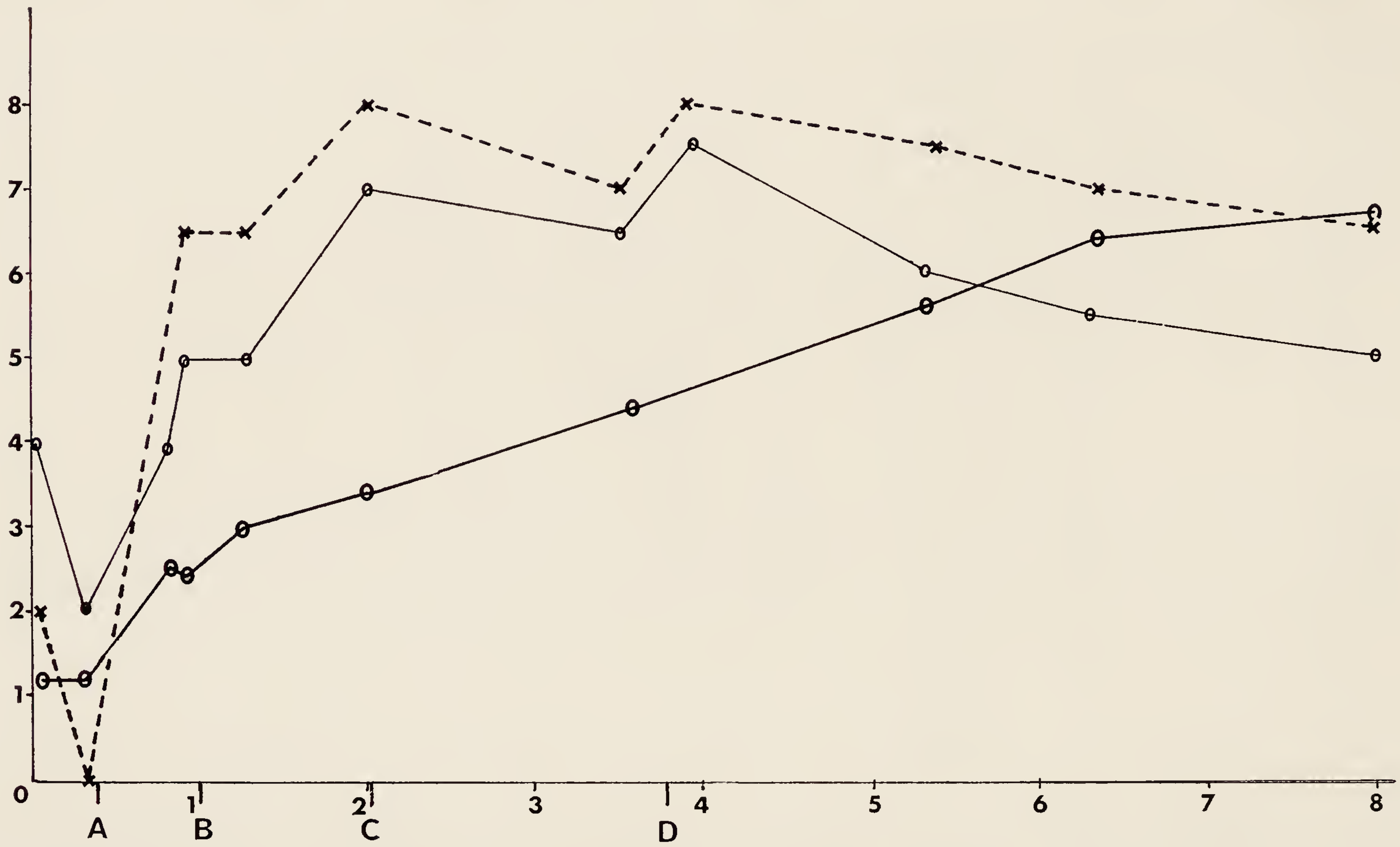


Fig. 8.—Graph showing values for maxillomandibular angles (broken line; degrees above 20°), angle of line SN to mandibular plane (thin line; degrees above 25°), and facial percentages (thick line; percentage above 50 per cent), for case R.C. Horizontal ordinate in years from 1 January, 1955. A, Point at which the upper appliance was inserted. B, Upper incisors reported labial to lowers (but radiograph taken with the mandible displaced forward, and molars in occlusion). C, Posterior teeth have erupted into occlusion, with normal incisor relation. D, Appliance withdrawn.

Table IV.—Details of Eight Cases with Low Maxillomandibular Angle

Individual's Initials	Time under Observation	Change in M/M Angle	Change in Facial Per Cent	Increase of Lower Facial Height	Increase of Upper Facial Height
Control group	5–1	−0·48	+0·59	+ 3·4	+1·25
G.S.	2–7	0·0	+1·73	+ 5·5	+1·5
L.U.	2–9	0·0	+0·67	+ 4·0	+2·0
R.C.	9–0	+6·0	+5·77	+22·0	+5·5
D.S.	8–6	+0·5	+2·29	+ 7·0	+1·5
J.D.	6–8	−2·0	+3·97	+14·5	+3·5
S.S.	3–6	−0·5	+1·35	+ 4·5	+1·5
A.N.	10–9	−3·0	+0·77	+11·0	+8·0
C.K.	7–0	−5·5	+0·90	+ 8·5	+4·5

having a ' reduced overbite '. Those with the upper incisor overlapping more than two-thirds of the lower incisor were regarded as having a deep overbite, while the intermediate group was regarded as ' normal '. This last group was ignored, and the two extreme groups compared. There were fifteen cases with a reduced overbite, and nineteen in whom it was increased. The results are given in *Table III*. It will be seen that

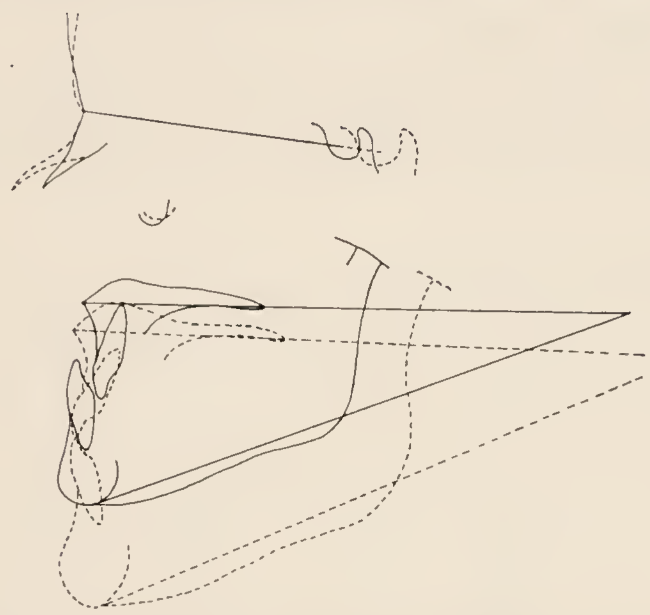


Fig. 9.—First and last radiographs of R.C. superimposed on line SN, with N registered.

see how the former could be affected by relief of overclosure. It would seem to be a feature of growth.

The most unusual case is undoubtedly ' R.C. ', and it was decided to investigate this case further, as this patient had an exceptionally complete series of lateral radiographs. *Fig*. 8 is a graph for two angles—maxillomandibular angle and SN-mandibular plane, and also the facial percentage, above certain designated values. The horizontal values are for time. Both the maxillomandibular angle and facial percentage increase during treatment, and both show some tendency to return towards their original values following treatment. The angle between the mandibular plane and the line SN also increases during treatment, but later returns to within only 1° of the original value. *Fig*. 9 shows the original and final tracings for this patient, superimposed on the line SN with N registered. It will be seen that the face has grown in a regular manner, except that the anterior end of the maxillary plane has descended less than the posterior end. This factor has given rise to the apparently abnormal changes in the two values.

This apparent ' tilting ' of the maxillary plane relative to other planes of the head was seen in a

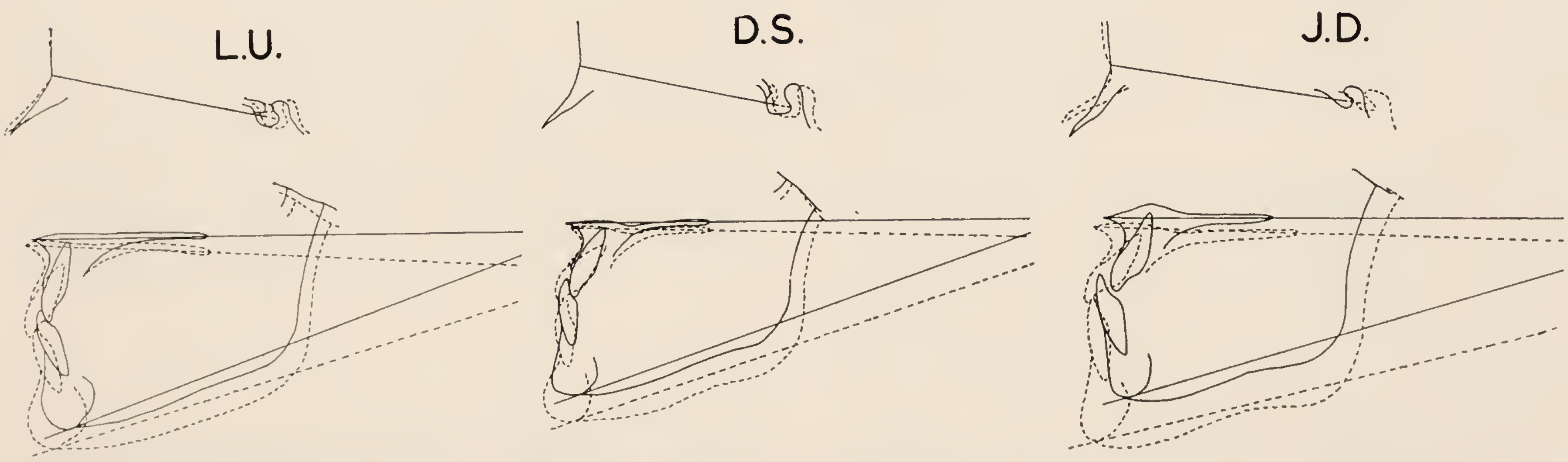


Fig. 10.—Three further cases from those considered in *Table IV*, superimposed as in *Fig*. 9, to show ' tilting ' of maxillary plane.

the difference between the two groups, for changes in mandibular angle, is negligible. There is rather more difference of change in facial percentage, and this almost reaches the ten per cent level of significance. However, similar differences were seen in the control group, when divided according to the overbite, although the numbers were too small for statistical analysis.

I next investigated those eight cases in whom the initial maxillomandibular angle was 22° or less. The results are shown in *Table IV*. In only one case does the maxillomandibular angle increase to an appreciable extent, and it actually decreases in four. The only noticeable factor is that many of these cases show more vertical growth than one would expect, but this occurs in both upper and lower facial heights; one cannot

total of four of the cases in *Table IV*, the remaining three being shown in *Fig*. 10. It would appear to explain the increase in facial percentage in these cases, and might repay further investigation.

Brodie has suggested (Brodie, Downs, Goldstein, and Myer, 1938) that an increase in maxillomandibular angle is confined to patients treated in the adult dentition. It was found to a slight extent in only one of the four adults in this sample.

One can, therefore, say with some certainty that overclosure of the mandible is not a common feature of Class III malocclusion. No definite evidence of it was found in any of the cases studied, although one cannot, with a sample of this size, say that it never occurs.

The Incisor Relationship

It is customary to indicate the position of the incisors by consideration of the angle which their long axes make with the maxillary and mandibular planes. While this measurement is of value, it does not tell us everything about the changes which occur. A change in angulation may be due to a movement of the incisal edge, root apex, or both. To assess all these factors I therefore measured:—

1. The angle of the long axis of the upper incisor to the maxillary plane (CR/XP in *Fig.* 1 B), and of the lower incisor to the mandibular plane (IL/MG).

2. The angles SNC, SNR, SNI, and SNL. These indicate the position of the incisal edges and apices relative to point N, but they will be affected by any simultaneous changes in the apical bases.

3. The angles ANC, ANR, BNI, and BNL. These indicated the positions of the incisal edges and apices relative to the 'dental bases', as represented by points A and B.

The Upper Incisor

The angle of the upper incisor to the maxillary plane before treatment was very similar to that in the control group (*Table V*). This corroborates

Table V.—Assessment of Incisor Position

	Experimental Group		Control Group		Significance	
Upper Incisor *Conditions in first radiograph*	*Mean*	*S.D.*	*Mean*	*S.D.*	*t*	*P*
CR/XP	111·27	5·73	112·10	5·76	0·517	0·70
SNC	80·82	2·91	83·85	3·29	4·009	0·001***
ANC	2·24	1·81	2·50	1·69	0·598	0·60
SNR	72·08	3·49	76·02	2·54	3·087	0·01**
ANR	−6·59	1·84	−4·94	1·12	3·983	0·001***
Short-term changes						
CR/XP	+7·00	5·96				
SNC	+1·95	1·38				
ANC	+1·60	1·32				
SNR	+0·59	1·46				
ANR	+0·24	1·38				
Long-term changes						
CR/XP	+7·27	5·84	+0·79	3·29	5·175	0·001***
SNC	+2·56	1·90	+0·48	1·25	4·983	0·001***
ANC	+1·92	1·42	+0·48	1·11	4·433	0·001***
SNR	+1·74	2·14	+0·52	1·13	2·677	0·01**
ANR	+1·09	1·54	+0·52	0·91	1·709	0·10
Lower Incisor						
Conditions in first radiograph						
IL/MG	84·82	6·74	94·04	4·85	6·106	0·001***
SNI	83·08	3·34	81·07	3·62	2·487	0·02*
BNI	2·39	1·77	3·46	1·24	2·813	0·01**
SNL	77·20	3·24	74·50	3·07	3·452	0·001***
BNL	−3·40	1·26	3·62	0·81	0·724	0·50
Short-term changes						
IL/MG	−6·73	6·30				
SNI	−2·09	1·91				
BNI	−1·47	1·79				
SNL	+0·14	1·34				
BNL	−0·88	0·94				
Long-term changes						
IL/MG	−6·24	5·59	+0·29	3·55	4·866	0·001***
SNI	−0·81	1·90	+0·56	1·62	3·084	0·01**
BNI	−1·31	1·39	+0·04	0·80	4·521	0·001***
SNL	+1·22	1·82	+0·52	1·38	1·692	0·10
BNL	−0·96	0·81	+0·17	0·90	5·432	0·001***

* Difference just significant; 5 per cent level.
** Difference significant; 1 per cent level.
*** Difference very significant; 0·1 per cent level.

findings of Maj, Luzi, and Lucchese (1958), Bjork (1947), and Freunthaller (1964), although Joffe (1965) found that the upper incisors tended to be rather more proclined relative to the line NA—a line affected in turn by the maxillary retrognathism. Similarly, in my sample, the angles SNC and SNR are lower in the experimental than in the control group, but this again merely reflects the lower SNA angle.

The angle ANC did not differ from the control group, but the angle ANR was 1·6° greater in the experimental group, indicating a more lingual position of the upper incisor apex. This difference was very significant. Although the angle of the upper incisor to the maxillary plane, in the first radiograph, was similar in both groups, it would seem that the incisor was slightly more proclined in the experimental group, if the line SN was used as the base.

In the short term the upper incisors had been proclined through a mean angle of 7°, although with wide individual variations. This was largely due to labial movement of the incisal edge, the root apex moving lingually only very slightly relative to point A (angle ANR). In the long term, the proclination of the upper incisor was maintained or even slightly increased, the change still being very largely due to labial movement of the incisal edge. All the long-term changes seen are significantly different from those in the untreated control group except ANR, which only approaches significance. The difference between short-term and long-term changes is slight, and it would seem that the final position of the upper incisor is assumed shortly after the completion of treatment, and thereafter there is but little change.

The Lower Incisor

The lower incisor was initially 10° more retroclined in the experimental than in the control group. Similar findings were reported by all the above authors. This confirms a clinical impression that nature tends to compensate for a Class III skeletal pattern by a natural retroclination of the lower incisors, presumably as a result of soft-tissue activity. The standard deviation is rather large, but even so the condition applies to the vast majority of individuals. From a consideration of the angles BNI and BNL it would appear that this difference between the two groups is due to a lingual displacement of the incisal edge with only a slight labial displacement of the root apex.

In the short term the lower incisors are tilted even further lingually, the incisal edge moving lingually rather more than the apex moves labially. The long-term result shows little further change; perhaps a little proclination, with both incisal edge and apex moving labially.

On average, then, the Class III incisal relationship was corrected by approximately equal proclination of the upper incisor and retroclination of the lower. Any relapse is likely to occur immediately after treatment (the second of the ' short-term ' radiographs was not necessarily taken immediately incisal correction had been achieved). There was no further long-term change, except that both incisal edges have moved labially slightly. In the maxilla the proclination of the incisors was largely a result of labial movement of the incisal edge, with only a little lingual movement of the root apex. In the mandible, both ends of the tooth moved in opposite directions, so that tilting took place about a point roughly in the middle of the tooth; not very far below the alveolar crest.

The range of individual changes, represented by the standard deviations, is quite large. It was felt that this might be due in part to the different treatment methods employed. Of the forty-four cases, eleven were successfully treated by proclination of the upper incisors only; nineteen by a combination of proclination of the upper incisors and retroclination of the lowers; five by retroclination of the lower incisors only; and nine by various combinations of treatment which made them difficult to classify. It was therefore decided to compare the first two groups. For convenience they will be called the PU group (treatment by upper proclination only) and the PURL group (treatment by proclination of upper and retroclination of lower incisors). Both groups contain only successfully treated cases.

As might be expected, the characteristics of the two groups are not identical (*Table VI*). Both exhibited definite Class III skeletal patterns, but this is more marked in the PURL group. In particular, the PU group did not show the low value of SNA which was a feature of the PURL group. The maxillomandibular angle was high in PURL and low in PU, although the standard deviation was large in both groups. The incisal positions showed less difference between the two groups, although there was a suggestion that the upper incisors were more proclined in the PURL group, partially compensating for the retroposition of point A.

The short-term changes reflected the methods of treatment. In the PU group the incisal changes were largely confined to the upper jaw, while in the PURL group they were more equally divided with rather more change in the lower jaw. The anteroposterior changes in the skeletal pattern were small, and similar in both groups, in both short and long terms. In the vertical dimension both maxillomandibular angle and facial percentage increased slightly in the PURL group and decreased slightly in the PU group, but this difference had largely disappeared in the long-term results.

The changes in incisal position showed less difference between the two groups in the long

Table VI.—COMPARISON OF RESULTS OF TWO METHODS OF TREATMENT

		Group PU		Group PURL		Significance	
Conditions in first radiograph		*Mean*	*S.D.*	*Mean*	*S.D.*	*t*	*P*
	SNA	80·32	3·32	77·63	3·40	2·256	0·05*
	SNB	81·82	2·36	80·03	3·16	1·752	0·10
Skeletal	ANB	−1·50	1·74	−2·39	2·14	1·261	0·20
Points	M/M Angle	23·36	3·00	29·24	5·19	3·671	0·001***
	Facial percentage	53·50	1·62	54·73	2·09	1·803	0·10
	CR/XP	108·68	7·16	109·82	5·31	0·532	0·60
Upper	SNC	81·50	3·40	80·32	3·33	1·000	0·40
Incisors	ANC	1·27	1·69	2·71	1·78	2·328	0·05*
	SNR	74·32	3·65	71·18	2·84	2·817	0·01**
	ANR	−5·45	1·50	−6·50	1·19	2·256	0·05*
	IL/MG	86·95	9·12	83·24	8·12	1·211	0·30
Lower	SNI	83·77	3·28	82·13	3·36	1·396	0·20
Incisors	INB	2·00	1·88	2·13	1·56	0·221	0·80
	SNL	78·41	1·91	76·39	3·27	1·998	0·10
	LNB	−3·59	0·70	−3·55	1·08	0·115	0·90
Short-term changes							
	SNA	+0·45	0·61	+0·34	0·69	0·480	0·70
Skeletal	SNB	−0·18	1·19	−0·58	0·91	1·110	0·30
Points	ANB	+0·54	1·33	+1·0	1·45	1·014	0·30
	M/M Angle	−0·32	0·93	+0·89	1·16	2·442	0·05*
	Facial percentage	−0·04	0·51	+0·71	0·87	2·791	0·01**
	CR/XP	+9·68	4·70	+5·50	6·00	2·117	0·05*
Upper	SNC	+2·77	1·49	+1·74	1·19	2·246	0·02*
Incisors	ANC	+2·52	1·52	+1·34	1·03	2·255	0·05*
	SNR	+0·36	1·61	+0·82	1·27	0·913	0·40
	ANR	+0·09	1·62	−0·45	1·04	1·192	0·30
	IL/MG	−1·27	4·36	−9·08	6·15	3·969	0·001***
Lower	SNI	−0·54	1·54	−2·50	2·07	2·914	0·01**
Incisors	INB	−0·36	1·13	−2·00	2·15	2·502	0·02*
	SNL	−0·23	1·21	+0·18	1·56	0·804	0·40
	LNB	−0·04	0·52	−1·08	0·83	3·99	0·001***
Long-term changes							
	SNA	+1·00	0·74	+0·48	1·35	1·249	0·30
Skeletal	SNB	+0·41	1·11	+0·45	1·54	0·769	0·50
Points	ANB	+0·59	1·51	−0·03	0·84	1·547	0·20
	M/M Angle	−0·77	3·18	−1·37	3·03	0·553	0·60
	Facial percentage	+0·94	1·85	+1·09	1·10	0·300	0·80
	CR/XP	+9·14	4·38	+5·34	7·37	1·664	0·20
Upper	SNC	+3·73	0·98	+1·74	1·95	3·382	0·01**
Incisors	ANC	+2·73	0·97	+1·47	1·74	2·361	0·05*
	SNR	+2·23	2·25	+1·31	1·68	1·359	0·20
	ANR	−1·32	1·95	−0·89	1·39	0·744	0·50
	IL/MG	−1·41	4·69	−8·44	6·43	3·344	0·01**
Lower	SNI	−0·09	1·45	−1·08	1·18	2·182	0·05*
Incisors	INB	−0·63	1·21	−1·55	1·20	2·153	0·05*
	SNL	+0·73	1·36	+1·76	1·58	1·945	0·10
	LNB	−0·32	0·56	−1·29	0·75	3·99	0·001***

* Difference just significant; 5 per cent level.
** Difference significant; 1 per cent level.
*** Difference very significant; 0·1 per cent level.

term than in the short term, but they were still present. In general terms, the upper incisal edge (angle ANC) was about $1\frac{1}{4}^\circ$ further forward in the PU group than in the PURL group, although the position of the apices was similar in both groups. In the lower jaw, the incisal edge was about 1° (angle BNI) further forward in the PU group, while the apex was affected to a similar extent, but in the opposite direction.

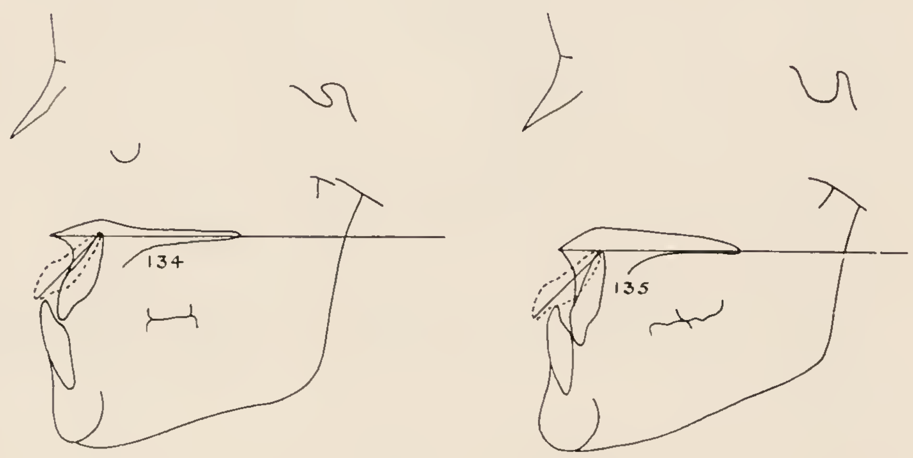
In a previous paper of the present series (Mills, 1964) I investigated the effect on the intact lower arch of the extraction of $\overline{4|4}$ in the absence of orthodontic treatment. This showed a decrease in the angle BNI of 0·83°; almost exactly the difference between the two groups considered here. Now, in the PU group, with treatment confined to the upper arch, the lower arch remained intact throughout treatment in all cases (although in one case $\overline{6|6}$ had been lost some time before treatment was commenced). In the PURL group, on the other hand, teeth were extracted in the lower arch in all but one case. In this one case the lower teeth were spaced before treatment, so that there would be no support of the labial segment by the buccal teeth. It is suggested, therefore, that the long-term difference in position of the lower, and therefore of the upper, incisal edge was not due to the different appliances used (although these have an effect in the short term), but to the lack of support from the buccal segment of teeth in the PURL group. The more labial position of the lower incisal apex in this group, being less under the control of the soft tissues, was more directly the result of appliance therapy.

It should be emphasized that all the changes seen in anteroposterior position of the incisal edge and apex were quite small. A change of 1° in the angle SNC or SNI is equivalent to only about $1\frac{1}{3}$ mm., being slightly less for SNR and slightly more for SNL. Fortuitous combinations of apical and crown movement can, however, give rise to quite large changes in incisal angulations.

CONCLUSIONS

There was no evidence that treatment of Class III malocclusion had any permanent effect on the skeletal pattern, although there may be alveolar remodelling around point A in some cases following incisal proclination. In a few cases an apparent reduction in the angle SNB could be accounted for by the elimination of a forward displacement of the mandible on closing. There is some increase in lower facial height immediately following treatment, a common occurrence following many types of orthodontic treatment, but this disappears over a longer period. There was no evidence of overclosure being present, or of its being eliminated as a result of treatment, but a study of this nature cannot eliminate the possibility of its occurring as a rare phenomenon.

It is suggested that the further subdivision of Class III malocclusion is liable to be misleading. The so-called ‘pseudo-Class III’ case, caused by environmental factors, must be excessively rare. A patient’s ability to achieve edge-to-edge incisor relationship is not a diagnostic criterion in this context; most of the patients in this study had this ability, including some with severe skeletal discrepancies. Further, the division of Class III malocclusion into two groups depending on the maxillomandibular angle would seem false when the distribution of this angle in the sample is so close to a normal one, with the modal value close to the mean. The lower facial height, like the anteroposterior skeletal pattern, is a continuously variable factor, and both are most important in assessing prognosis and planning treatment, but both should be assessed as continuous variables, as with most diagnostic features.



A B

Fig. 11.—Two cases with very deep overbites, showing (broken incisor outlines) the amount of proclination which would be necessary to correct the reverse incisor relationship.

The lower facial height is particularly important in the comparatively few extreme cases, because of its effect on incisor overbite. Where the lower facial height is much above average, there is a lack of vertical overbite, and nothing to retain the corrected incisor relationship, which therefore relapses. A much reduced lower facial height is usually associated with a very deep overbite. If one accepts my premise that this is inherent in the individual, it is possible to explain why these cases present problems, especially if an attempt is made to correct the condition by proclination of the upper incisors only.

Two such cases are shown in *Fig.* 11. In both of these, the upper incisors were proclined, with no other tooth movement. If we assume that the incisor tilted about its apex (the most favourable possibility), the upper incisor would have to be proclined to a quite impossible extent to clear the lower incisors in occlusion. In fact, from a study

of individual cases, it would seem that one of two possible courses will be followed.

In one group (*Figs.* 11 A, 12 A) the upper incisors commence to procline. During normal function, the patient occludes the posterior teeth from time to time. As the upper incisor proclines, it presses labially on the lower incisor, which therefore also proclines. Gradually, both procline further until they meet in an edge-to-edge relationship, which is, however, unstable. This is shown in *Fig.* 12 B, which is traced from an actual case.

The alternative is shown in *Figs.* 11 B, 13 A. Here the upper incisors alone procline until the state arises where, if the patient closes in centric jaw relationship, there is a normal overbite and overjet (*Fig.* 13 B). In this position there is a posterior open bite, and the mandible is

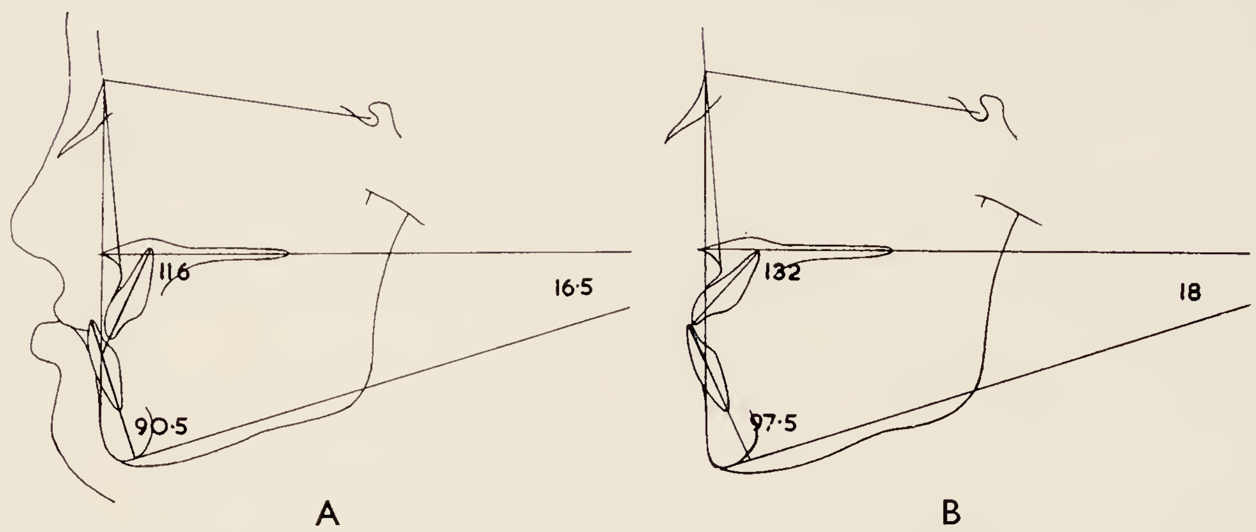


Fig. 12.—Same case as *Fig.* 11A, showing A, the condition before treatment, B, the result of an attempt to procline the upper incisors.

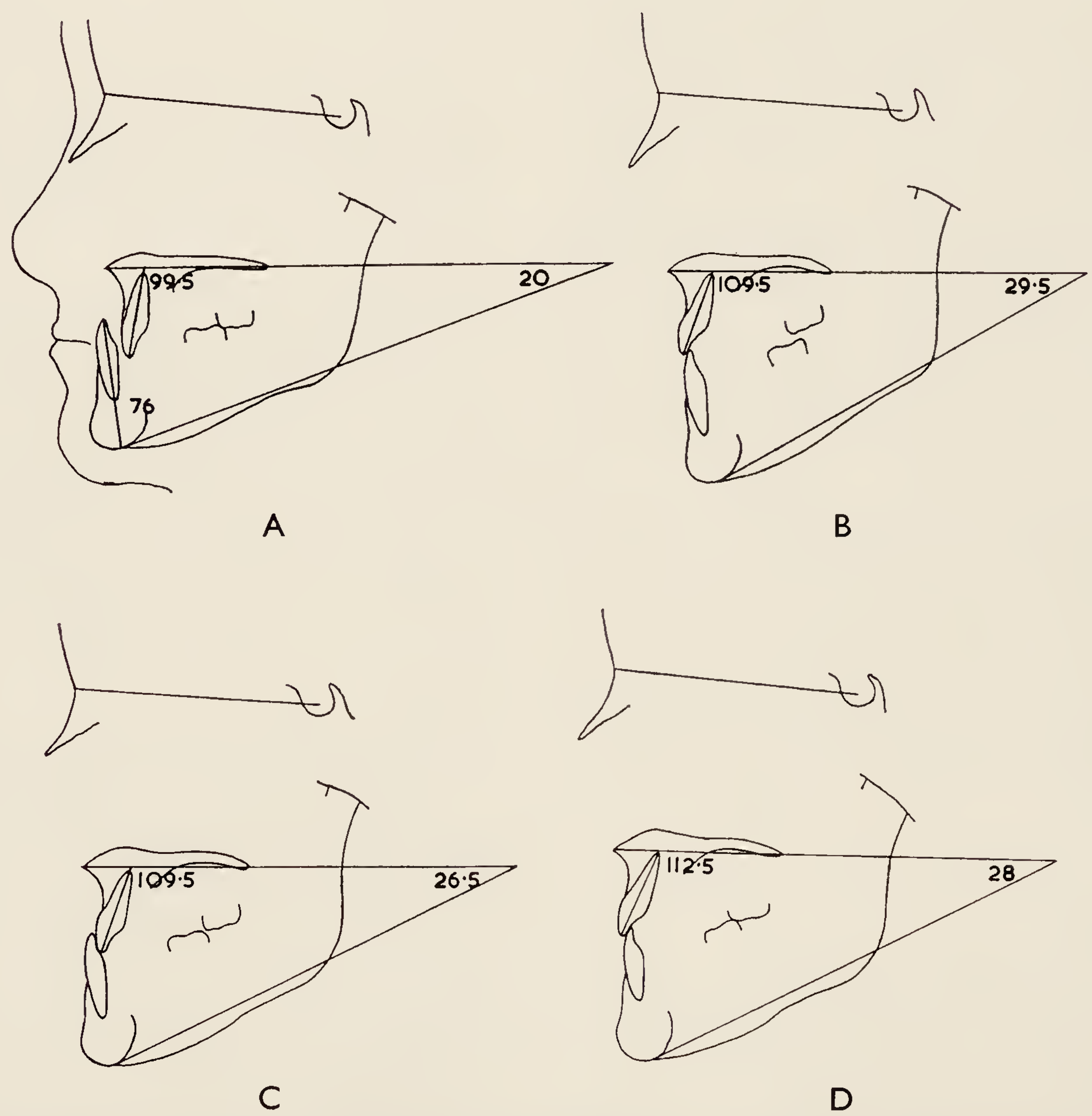


Fig. 13.—Same case as *Fig.* 11B. A, Case before treatment. B, At this stage the incisors were reported to be in normal relation, but with posterior open bite (reconstruction). C, But radiograph was taken in occlusion, with the mandible displaced forwards. D, By this stage the posterior teeth had developed vertically into occlusion with some depression of the anteriors.

'over-opened'. At this stage, if the patient is asked to close his posterior teeth, he will do so by further protrusion of the mandible. In this patient *Fig.* 13 C represents the case with the posterior teeth in occlusion at a time when the clinical notes state that the incisor relation was correct, although with a posterior open bite. *Fig.* 13 B is reproduced from *Fig.* 13 C by repositioning of the mandible as described in the patient's case notes. An impossible amount of further proclination would be necessary to allow the mandible to return to its true vertical position, with the posterior teeth in occlusion (*Fig.* 11 B). If this condition is retained by means of an appliance with an anterior bite plane, the posterior teeth will erupt further, and may or may not come into occlusion, depending on the eruptive potential remaining. The mandible will also tend to revert to its natural vertical position, with depression of the anterior teeth, and further proclination of the upper incisors (*Fig.* 13 D). This may give rise to traumatic occlusion of the incisors.

Both of these responses have been seen in a number of patients, and there is no firm evidence to suggest why the response should be different. An examination of the soft-tissue outlines, and of the lower incisor angulation, in *Figs.* 12 A and 13 A might suggest that the lip musculature is weaker or less active in the former type of case. These cases with very deep overbite are more likely to be successfully treated if the lower incisors are retroclined in addition to upper proclination, but they always present a problem.

The changes in incisor position in the whole sample are essentially as one would expect. The short-term changes reflected the method of treatment, but there was some settling down in the long term. Where the upper arch alone was treated, the incisal edges of the upper and lower incisors were about $1\frac{1}{4}$ mm. further forward than they would have been without treatment (as well as being in reversed relation to each other). This was probably due to the supporting effect of the intact lower arch. Where both arches were treated, with no support from the lower buccal segments to the lower incisors (usually as a result of lower extractions), the incisal edges of upper and lower incisors essentially changed places. This would seem less likely to give rise to traumatic occlusion, and might well be more stable. Hopkin (1962) found essentially similar results, except that he found more lingual movement of the lower incisors in his 'PU' group. His cases were all in the mixed dentition, whereas mine were divided between mixed and complete permanent dentitions and it may be that this lower retroclination occurred in Hopkin's group when the buccal support was temporarily missing during tooth replacement.

The methods of tooth movement differ in the two jaws. In the upper, labial movement of the incisal edge accounts for most of the proclination, whereas in the lower jaw, incisal edge and apex move to almost equal extents. In fact very little movement is required in any of these sites to correct the incisal relationship. Both the mean values and standard deviations are quite small.

It would seem that the best method of treatment of a Class III malocclusion is to procline the upper incisors and simultaneously retrocline the lowers, so that they remain in a position of muscular balance. Extractions in the lower arch will usually be necessary to achieve this. Treatment by proclination of the upper incisors only has the advantage of simplicity, but is most likely to be successful in a patient with a mild Class III or normal skeletal pattern, in whom any skeletal abnormality is confined to the lower jaw. The maxillomandibular planes angle should be on the low side, but not very low. It is more likely to be successful in the mixed dentition. Although there were eleven cases in this sample of forty-four individuals who were successfully treated by proclination of the upper incisors only, there were eight who were unsuccessfully treated by this method, but later successfully treated by other methods.

Acknowledgements

I would thank especially Miss G. T. D. Pickard, who traced and measured all the radiographs, and helped in many other ways. I would also thank my colleagues at the Eastman Dental Hospital, London, and especially Professor C. F. Ballard and Mr. S. G. McCallin, who freely placed records of their patients at my disposal; Mr. G. G. T. Fletcher, who read the manuscript, and Miss J. Jeffrey for secretarial assistance.

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DISCUSSION

Dr. G. B. Hopkin, opening the discussion, said he appreciated Dr. Mills' difficulty with regard to the control sample. Could he give the individual numbers in each group, together with the sexes, because there was such a difference around that age period between boys and girls? It might be interesting to know whether the sample was weighted with one sex.

He agreed with Dr. Mills that treatment did not change the basic skeletal pattern. There was a slight reduction in the angle SNB in some cases, which was transient. The only cases showing a marked change was those involving the elimination of a functional protrusion.

In his experience, overclosure was a common feature; he had met it. He remembered one very remarkable case where, at rest before treatment, there was a very large freeway space, and after treatment, with the incisors in their correct position, there was initially a large posterior open bite. Over a period of two years there was molar eruption of about 7 mm. Sometimes such a posterior open bite did not close and one was faced with what Blyth called a failure of vertical development.

He agreed most heartily that a Class III skeletal pattern was a basic factor in initiating Class III malocclusion. He agreed with Dr. Mills' definition of Class III, and this was why he termed the condition mesioclusion, thus avoiding the confusion of Angle's classification.

Rather interestingly, he had two patients in whom he had been able to follow the eruption of the lower permanent incisors, to see the effect on them of the eruption of the upper incisors in lingual occlusion. As a result, they proclined 2° or 3°, and when the upper incisors were moved over the bite the lower incisors moved back to where they were before eruption, which suggested that there was a factor of balance labio-lingually. If such cases were treated early enough, nature would help, but this did not occur in the older patient, because of support from the lower buccal teeth, and one had to combine it with lingual movement of the lower incisors.

He was not clear about Dr. Mills' attitude towards the importance of the facial pattern. He found it helpful to think of three types in mesioclusion. The commonest was a mild Class III, which differed little from normal, and in fact was the sort of face about which Helm had said it differed so little from normal that it was a wonder Class III occlusion was so rare. The other two were those Dr. Mills had mentioned; the broad face with the reduced facial height and mandibular angle, and the long lean face, lantern-jawed, with a large mandibular angle.

He had come to these facial types not primarily by clinical observation. He had measured some 230 Class III patients, having split them up according to the degree of maxillary and mandibular protrusion, and had landed up with three main groups. The first, the mild Class III type, had protrusion of upper and lower jaws within one standard deviation of the normal in the control sample, but there happened to be an adverse combination. The second group were those in which the degree of protrusion of the upper jaw was within one standard deviation of the normal, whereas in the lower jaw it was greater than one, while the third group consisted of those with the mandibular protrusion within one standard deviation, but the maxilla retruded beyond this range. So there were three groups; mild, protruded mandible, and retruded maxilla.

On looking at the rest of the measurements of these faces, maxillomandibular planes angle and facial heights were outward and visible signs of inward and tangible differences. In the mild group all the measurements were within the range of normal except that there was a tendency for the anterior cranial base to be shorter and for the base angle to be smaller. In the second group, there was a marked trend to small cranial base angle and reduced mandibular angle. There was also a tendency to increase in the length of the horizontal ramus of the mandible, and to reduced facial height. The third group, with the long facial height, was interesting because the maxilla was short and narrow and the mandibular angle was high. The cranial base angle was normal, and the posterior cranial base length was significantly shorter. The point was that there were three variables; the cranial base, maxilla, and mandible.

Incidentally he thought Dr. Mills' use of facial percentages might be misleading, because the height of the maxilla was divided between upper and lower face.

He felt that the division into these types was valuable even though intermediate cases existed.

Coming to his queries, Dr. Mills mentioned relapse occurring soon after treatment. He assumed he meant relapse of the incisal inclination, and not long-term relapse except insofar as if patients were being treated after pubertal growth, relapse would not be such a problem as in the mixed dentition, where the growth spurt of puberty was a danger period.

In the case where Dr. Mills suggested that proclination of the upper incisors had caused simultaneous proclination of the lowers, he assumed that there was no capping on the appliance.

With regard to the suggestion that the patient showed a tilt of the maxillary plane, he noted that Dr. Mills was superimposing on nasion. Keith and Campion had shown that this point could move up and down during growth, and for this reason he had used De Coster's line.

Dr. Mills, in reply, said he would give details of the two groups in the published paper. The control group showed a reasonably narrow age range, but the experimental group was much wider, and he realised that they were not strictly comparable.

He was not at all convinced that he had ever seen a case in which there was a hyperactivity of the mandibular elevator muscles, as a result of which the chin was nearer to the nose, in occlusion, than it should be, and that this condition could be corrected when the incisor occlusion was corrected. Turning to the typing of facial patterns, he thought that this produced oversimplification, and often confusion when one found, with most cases, that they did not fit clearly into any of the groups. He agreed with Dr. Hopkin that they were infinitely variable, and thought it better to diagnose them on this basis.

In the case about which Dr. Hopkin enquired, the posterior teeth were capped, although the appliance may have been left out from time to time.

He had found difficulty in picking out De Coster's line in his cases, although he agreed that it was

theoretically preferable. The SN plane had, however, the advantage of being widely used, making comparison with other work easier.

The President asked whether intermaxillary traction was used, this would also bring forward the upper first molars.

Dr. Mills agreed that, in its pure form, this would happen, although there were numerous modifications used in his sample.

Mr. H. L. Leech said Dr. Mills had mentioned the importance of retroclining the lower incisors during treatment. Did he feel that this was important to prevent traumatic occlusion of the incisor teeth.

He remembered ten years ago seeing a case with Professor Ballard in which a fairly severe Class III case had been treated by proclination of upper incisors, and some years later the patient exhibited gross resorption of the incisor roots.

Dr. Mills said he had also heard Professor Ballard mention this case. He had not encountered such a case himself, and he thought traumatic occlusion in such cases was rare. The incisors were often mobile for a time after treatment, but they usually tightened up in a few months.

Mr. F. Allan said the question with regard to failure or success also depended on method. It was not mentioned in the paper, and he wondered whether teeth were moved by simple tipping, or by bodily movement. The relapse with bodily movement was not the same as with tipping, and success often depended on putting the whole of the tooth in a new position and angulation. Begg, for instance, disregarded both soft tissues and skeletal pattern, and appeared to end up with a Class I occlusion whatever happened before.

Dr. Mills said that in none of these cases was there any attempt to move teeth bodily, and he would not have thought this indicated in Class III cases.

Mr. N. L. Hill said that he found it difficult to decide, in some borderline cases, whether to attempt treatment in the mixed dentition, or to extract lower premolars and treat in the full permanent dentition.

Dr. Mills agreed that some cases were doubtful; his golden rule was to defer treatment when in doubt.

CEPHALOMETRIC TREATMENT PLANNING AND ANALYSIS OF MAXILLARY GROWTH FOLLOWING BONE GRAFTING TO THE RAMUS IN HEMIFACIAL MICROSOMIA

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THE condition referred to in the title has been given a variety of names and that chosen, hemifacial microsomia, seems to fit the condition better than others, such as unilateral agenesis and unilateral facial necrosis (Walker, 1961). It is not the intention of the present paper to discuss the aetiology of these conditions, except to state that two main types may be differentiated. There is the so-called first arch syndrome (*Fig.* 1), described by Herbst and Apfelstaedt (1930), in which they suggested the whole sphere of influence of the first visceral arch may be affected, and in which the mandibular deficiency may be only one amongst other defects of development. Walker (1961) subdivides this condition into three types, depending upon the area affected. As far as facial development is concerned, it is the lack of growth of the condyle head of the affected side, either by the complete congenital absence of that structure or else through its diminished growth effect, that concerns this discussion. A similar appearance of lower facial asymmetry can also result from an acquired reduction or even complete cessation of growth of one condyle head (*Fig.* 2). In the latter case, ankylosis is often present, resulting from infection of the temporomandibular joint, whether from an external source or of haematological origin.

Examination of the patients and questioning of the parents will soon distinguish the acquired from the congenital asymmetry, the most obvious point of difference being the absence of other congenital deformities in the acquired conditions. In addition, where there has been infection, an external scar is often to be found in the region of the angle of the mandible, where drainage has been achieved. The two classes of malformation show some features in common, and these may be tabulated as follows:—

1. Deviation of the mandibular centre line to the affected side.
2. A tilt of the occlusal plane upward to the affected side.
3. Usually a reduction in the height of the nasal passage on the affected side. Although this may be apparent on external examination, it is best seen on the postero-anterior cephalometric X-ray.
4. The lower incisors lean over to the affected side.
5. There may be a unilateral cross-bite.

However, apart from the tilt of the occlusal plane, there is not usually any other deformity in the middle part of the face in the acquired condition. In the congenital, on the other hand, there is a reduced distance between the outer canthus of the eye and the external auditory meatus on the affected side, in addition to other defects reported. Accessory auricles and incomplete development of the pinna are easily seen, but more hidden defects may be found. Rocher and Fischer (1929) have shown weakness of the seventh nerve, and Canton (1860), Kazanjian (1939), Franceschetti, Brocher, and Klein (1949), and others have noted the underdevelopment of the mastoid process. Absence of the masseter was reported by Braithwaite and Watson (1949), and Kazanjian (1939). Another frequent anomaly is the occurrence of macrostomia, which was found by Braithwaite and Watson (1949), Wilson (1958), Rushton (1938), Falkowski (1954), and in two of the five cases of Kazanjian (1939). More rarely, the eye may be cystic on the affected side, as in the cases of

Presented at the meeting of the B.S.S.O. held on 19 May, 1966.

A B

Fig. 1.—*Case* S.S. Congenital microsomia. Whole of left side of face reduced. Dermoid of left eye. Normal left pinna. A, Before bone-graft. B, After bone-graft, but still splinted.

A B

Fig. 2.—*Case* S.J. Acquired microsomia. A, Original asymmetry. Middle third of face essentially normal except for tilt of occlusal plane (*Fig.* 12). B, Six months after second graft. Still almost symmetrical.

Braithwaite and Watson (1949) and Falkowski (1954), or absent (Glass, 1966). One of the cases in the present series (*Case* S.S.), had this defect. Tomes (1872), found the inferior dental canal to be absent in a specimen he examined and *Case* S.S. also showed no evidence of a canal when the mandible was sectioned in the lower part of the ramus, prior to bone grafting. In addition, this same case has a smaller first permanent molar on the affected side than on the normal. All the investigators referred to above have found either absence or reduction of the ascending ramus. The earliest reference to the conditions is probably that of Dugès (1827). In 1905 Ballantyne reviewed the condition of absent ramus.

PRINCIPLES OF CORRECTION

The more localized nature of the deformities in the acquired asymmetry gives a better prognosis for correction. In the congenital cases, certain of the deformities, such as the reduced distance between the outer canthus and the ear, are unalterable. The feature which both types have in common and which is open to surgical treatment, is the asymmetry of the lower part of the face. At first sight, the progress of the asymmetry in both types would appear to have been the same. That is to say, the deficiency of condylar growth on the affected side has resulted in the deviation of the centre line and has restricted the downward growth of the maxilla and also that of the nasal floor. If the view is held that maxillary surface deposition follows in the wake of the descent of the mandible, resulting from condyle growth, then the principle of treatment of the asymmetry should be to make an attempt to compensate for the lack of mandibular growth. This principle was applied by Falkowski (1954), who inserted an iliac crest graft in order that the soft tissues should not be deprived of functional and physiological stimulus. The graft took the form of a strut between termination of the deficient mandible and the glenoid fossa area. When the graft had taken, the resultant ankylosis was freed by the establishment of a false joint and the patient sent to an orthodontic centre for a functional appliance. Unfortunately, no follow-up was possible, because contact with the patient was lost. In the cases reported in this series, interstitial grafts have been inserted into the ascending ramus. Some of these have been reported by Osborne (1964). The preoperative positioning of the mandible and the subsequent follow-up have been studied cephalometrically.

TIMING

Before considering the techniques of pre-operative planning, some consideration will be given to the age at which the operation may be best carried out. If one is hoping for a growth response on the affected side, then it is best to choose a time of active alveolar growth. This is most likely to be found during the eruption of the permanent series of cheek teeth. Apart from these considerations, it is also necessary to have sufficient teeth for the retention of the splints. The upper and lower permanent incisors should be in place. Thus the child will be about 7 or 8 years of age when this is done. Kazanjian (1939), suggested that treatment should be delayed until the age of 12 years, and Braithwaite and Watson (1949) seem to agree with such timing. Lewin (1950) reported two cases, one of 20 months and the other 9 years of age, and suggested that treatment be delayed until an unspecified later age. Harris (1953), however, inserted interval grafts in two cases and performed the first graft in one of them at the age of 6 years. So far, this type of correction has not been attempted in older subjects and although a child's face will exhibit continuous growth, the adolescent growth spurt is said to occur at about the age of 13 years in boys and 11 years in girls. When this observation was made, however, it was based upon bitrochanteric width (Tanner, 1947). Unfortunately, there may be by then so much deformity in the occlusion, that any attempt to correct the mandibular asymmetry would seriously derange the function of the teeth. Parker (1962) reports a bone-graft in a girl of 13 years, but there does not appear to have been any gross derangement of the occlusal plane. Without doubt, the earlier the bone-graft can be inserted, the better it will be as far as maxillary growth is concerned, if it is believed, as Kazanjian (1939) suggested, that the deficient growth of the mandible on the affected side will also limit maxillary growth. The analysis to follow is an attempt to discover what changes occur as a result of bone grafting.

MATERIAL

Only 7 suitable cases of asymmetry have been encountered in the last three and a half years. In 5 of these the condition was acquired as a result of infection, 2 are congenital in origin and 2 of the acquired had unilateral ankylosis. The bone grafting was not performed by the same plastic surgeon, and when individual cases are considered it will be seen that some variation in technique has been employed.

METHOD

It has been found that patients with facial asymmetry are referred in about equal proportion to the plastic surgeon as well as to the orthodontist. In any case, a joint consultation is arranged during which the principles of the treatment are explained to the parents. At this visit, the suitability of the teeth for the purpose of carrying cast splints can be determined and any

A B

Fig. 3.—*Case* A.F. Congenital microsomia. A, Preoperative planning of centre line correction and amount of open bite created on normal and abnormal sides. B, The separation of the bone end to be filled by graft.

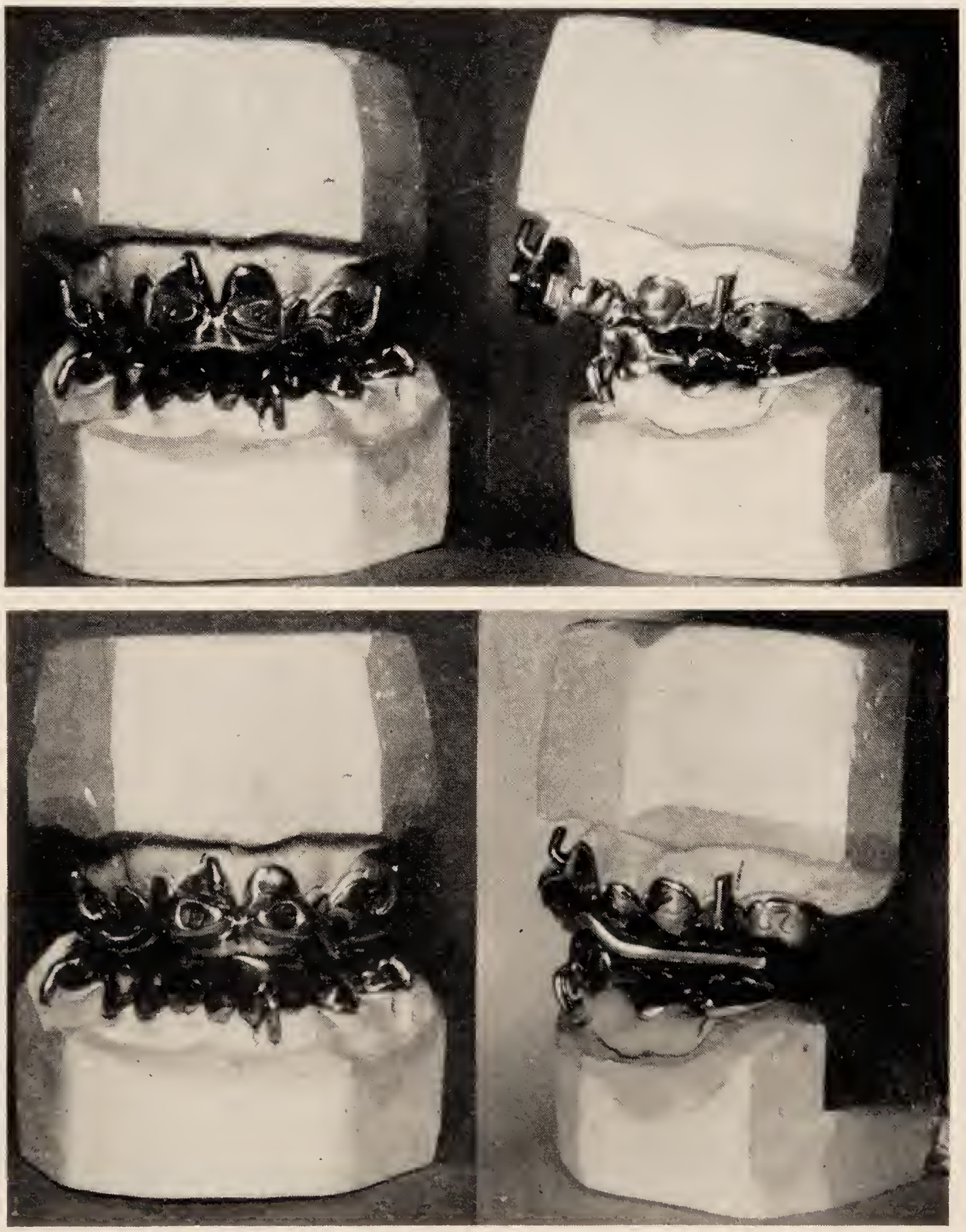


Fig. 4.—The splints: A and B, Without the bite blocks and showing the preoperative occlusion. C and D, Bite blocks in position, centre line corrected. Note relationship of the cleats and the separation of the cheek teeth.

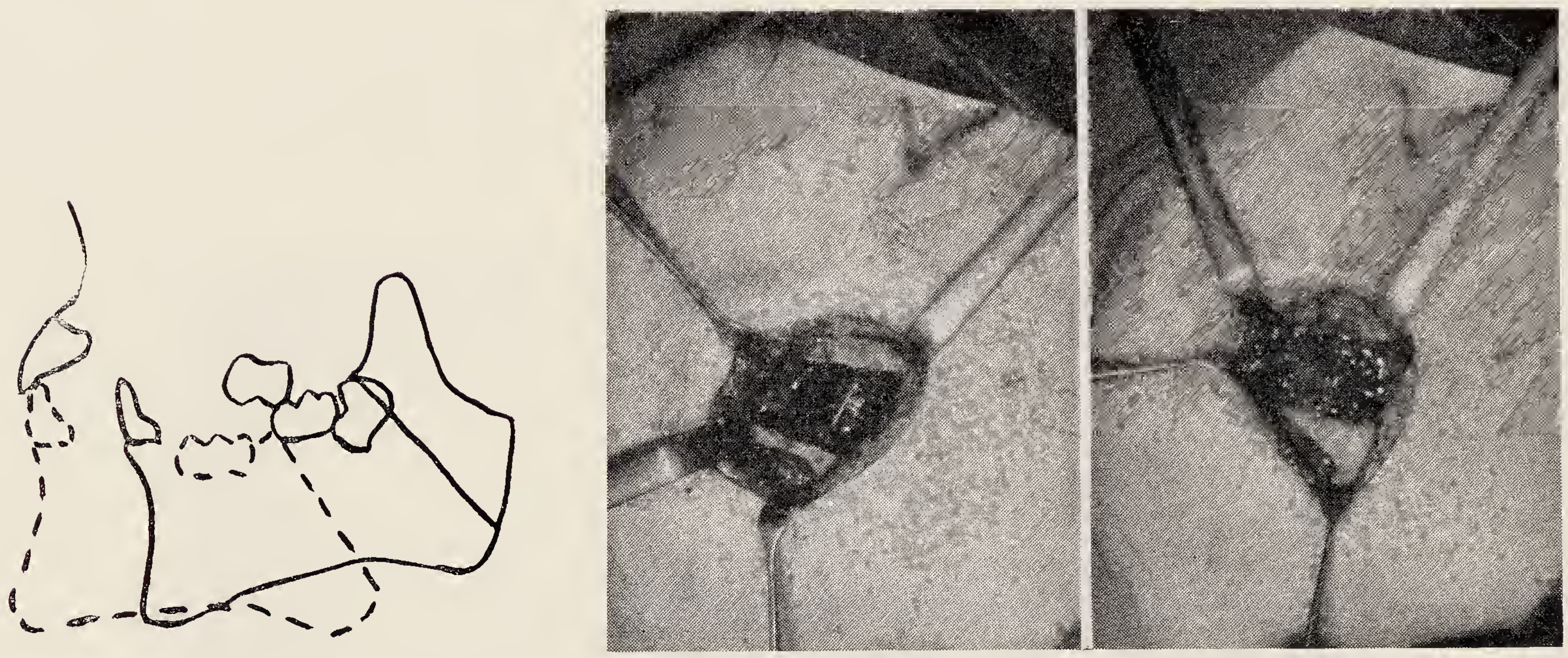
necessary dental treatment can be arranged, or it may be necessary to await the eruption of further permanent teeth before anything is done. In a severe case, however, the absence of teeth need not preclude the operation, since the retention of the splints can always be augmented by circumferential wiring. This has been used in one of the cases (*Case* S.S.). Assuming that conditions are favourable for the operation to proceed, the patient is referred for cephalometric X-rays, photographs, and study models. When these are to hand, the preoperative planning of the operation may be carried out.

If the cephalometric X-rays are to be of any use for this purpose, it is essential that the P/A film is taken with the Frankfurt plane horizontal as, of course, is the lateral film. It should then be possible to transfer vertical measurements from one to the other. From the lateral film, a tracing of the right and left occlusion is made. The study models will help in the identification of the teeth of each side. On the tracing from the P/A film, the mastoid processes and the orbital rims are drawn in, as these may form useful horizontal reference lines. One must be careful in using the mastoid processes routinely, because some investigators have shown that they can be underdeveloped. Separate tracings are now made of the mandibular structures from each of the three tracings already made, and these can be moved about until the desired new occlusion is achieved. This is a similar procedure to that for precision rami-section (Knowles, Kernahan, and Burston, 1963). The final position of the teeth on both the tracings and on the study models is usually as follows:—

1. The lower centre-line is over-corrected by $1\frac{1}{2}$–1 lower incisor widths, in relation to the centre-line of the head and not of the upper incisors, which are often also deviated to the affected side (*Fig*. 3).

2. There is an open bite of between $\frac{3}{4}$ and 1 cm. between the posterior teeth on the affect side and usually about $\frac{1}{2}$ cm. on the opposite side. This is the position to which the technician constructs the cast splints (*Fig*. 4).

3. The site of the bone-graft is the ascending ramus and with the teeth placed on the tracing of the affected side in the new position, it is possible to show the amount of new bone needed (*Fig*. 5).



A B C

Fig. 5.—A, Cephalometric tracing of corrected mandible showing separation of bone ends. B, Actual separation at operation. C, Chip bone-graft in place.

When there is a fair degree of concomitant retrognathia, the contralateral ramus may be sectioned and bone inserted, if necessary. This is when the normal side tracing is used.

Chairside and Preoperative Technical Work

All that is needed in the way of chairside work is accurate upper and lower impressions, preferably in a material that will allow the casting of duplicate models. One pair of models will form the study set, and these are orientated in the new occlusion and mounted on an articulator in this position for safe keeping. Using the models mounted in this way, the technician and orthodontist are able to determine the position of the following:—

1. The cleats for the attachment of the elastic fixation.

2. The siting of the locating plates to which the removable bite blocks are screwed.

The pull of the elastic fixation is arranged so that the rubbers in the incisor region have a slightly oblique direction, pulling away from the affected side. This has to be carefully judged because too great a pull would derange the predetermined new occlusion and distract the bone

ends during the early part of the organization of the grafted area (*Fig.* 6).

The Operative Procedure—the Splints

The splints are cemented on the day before operation and in young children it is of considerable help to administer atropine beforehand. The most unpleasant part of the cementation seems to be when cement-flavoured saliva is trickling down the throat. It is always considered worth while to polish the teeth before cementing, for fairly obvious reasons, not the least of which is the removal of any bacterial plaques. Care must be taken to ensure that cement does not enter the screw holes for the bite-block plates. These are carefully waxed out before the splints are cemented. A mouthwash of bicarbonate of soda is usually given to neutralize the acid of the cement.

In theatre, the items needed at the time of the fixation are laid on a separate trolley and consist of:—

1. The bite blocks and screws.
2. A selection of elastic bands, usually sizes 3's and 4's.
3. A hook for putting on the elastics.
4. Mirror, probe, and tweezers. These are used before or after induction of anaesthesia, to clean the wax out of the screw holes in the splints.

The Surgical Approach

The ramus of the mandible is approached through an incision below and parallel to the angle of the mandible. After blunt dissection through the platysma, care must be taken to avoid the marginal branch of the facial nerve when approaching the angle of the mandible. The ramus is cleared of both the masseter and the internal pterygoid, but in the congenital cases, the musculature may be vestigial. If a mandibular foramen is present on the evidence of the X-rays, then a template may be constructed (Knowles, 1966), so that the osteotomy may be made above the mandibular foramen. Although the direction of the cut in the horizontal plane is not important, it is usual to make it at a right angle to the posterior border of the ramus and also in the horizontal plane. When the ramus has been severed, some manipulation is usually necessary, in order to get the mandible into the optimum position. On the occasion of the first graft, this can generally be achieved from within the mouth, but with subsequent grafts the bone ends themselves may need to be parted with some force and strands of fibrous tissue cut (Osborne, 1964). When sufficient mobility has been achieved, the bite blocks may be screwed into place and the mandible immobilized with elastic fixation. On returning to the wound, a gap will be found between the bone ends, which must now be filled with bone-graft (*Fig.* 5 B, C). It is not the purpose of this article to discuss the merits of the various types of graft that may be employed, but a brief resumé will be given:—

1. A one-piece graft taken from iliac crest. In the case of a young child this must be homologous because the iliac crest still has a cartilaginous cap.

Fig. 6.—Elastic fixation in place. Same case as *Figs.* 4 and 5.

2. Autogenous rib. This causes very little discomfort in the child and regeneration is rapid.
3. Autogenous cancellous chips from the ilium. These can be taken without disturbing the pelvic rim, through a small window cut in the outer cortical plate, after the method of Flint (1964).

In the case of the one-piece graft and the split rib, interosseous wiring is employed. With rib, one piece is used as a spacer, the remainder being cut into small pieces to fill in the gap. There seems to be little tendency for the upper fragment to displace in cases of acquired agenesis, so that the cancellous chips can be used without the need for wiring. This unusual stability of the upper fragment may be due to the abnormal shape of the affected condyle head and glenoid fossa, and because the external pterygoid muscle has probably lost its attachment during the course of the infection. The temporal muscle, which remains attached to the coronoid process, will not be able to displace the fragment upwards, because the fore-shortened condyle neck that is present, allows the sigmoid notch to be closely applied to the region of the articular eminence (*Fig.* 7 B). There is also usually some limitation of movement to be found, particularly in lateral translation, in the acquired cases. Irrespective of the

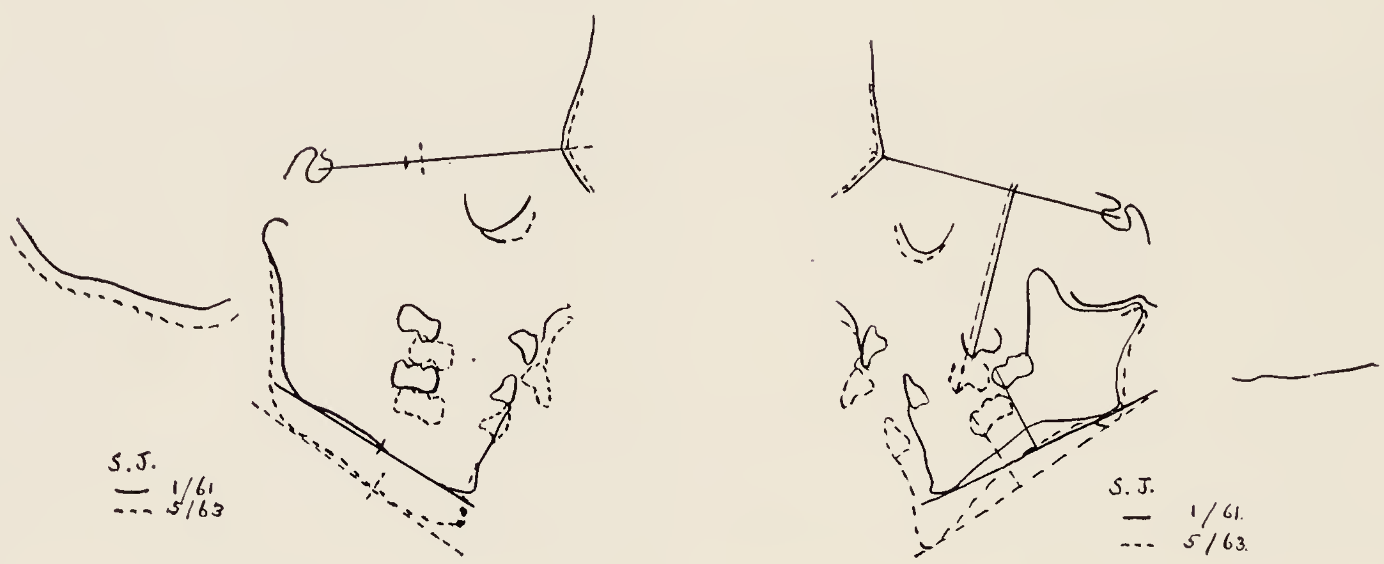
type of graft, union is usually achieved in five to six weeks. This can only be assessed on clinical examination, since the presence of bony union is not obvious radiographically after so short a period. At the end of the fifth postoperative week, the elastic fixation is removed and palpation of the mandible, whilst a few gentle movements are carried out, will soon tell if there is union. This, of course, only applies if there is a palpable mass representing the condyle region, the movement of which can be felt. A week is given for the patient to become accustomed to opening the jaw again after its period of fixation and then the splints may be removed.

Orthodontic Management

If there is a stable joint on the affected side, as there is in most of the acquired cases, then the posterior open bite that has been created can be left to the natural process of alveolar growth to ' fill in '. In those congenital cases, where there is not any joint against which the newly-acquired mandibular length may be buttressed, or in those who have had condylectomy, some form of orthodontic treatment is needed to cover the period when alveolar growth should occur, otherwise the posterior open bite will be closed by an upward swing of the mandible to the affected side, before alveolar growth has had time to take place. The appliance of choice is either the Andresen plate or an upper bite plate, with sufficient anterior flange to guide the path of closure away from the affected side. In this way, the mandible is held in its corrected position until as much alveolar growth as will occur, has occurred.

Cephalometric Observation

Lateral and postero-anterior exposures are taken at 6-monthly intervals postoperatively, and the progress of upper and lower molar alveolar growth on the affected side is measured. In addition, the relationship of the upper and lower centre lines is observed, and when the lower has again deviated to the affected side to the original amount a further bone-graft is recommended. The interval of time needed for this to happen varies between the congenital and the acquired, the former tending to relapse more rapidly than the latter in the absence of a stable joint on the affected side. Harris (1953) suggested 2-yearly intervals, but this was not based upon many cases. The cephalometric analysis will detail the individual changes that occur, but it will not be possible to reach any firm conclusions with the small number of cases as yet treated.



A B

Fig. 7.—*Case* S.J. Acquired microsomia. A, Normal side. Shows growth over 28-month period. B, Agenesis side. Note downward and forward growth of upper molar and close application of sigmoid notch to the articular eminence.

Cephalometric Analysis

Four of the cases have now had two bone-grafts each, and cephalometric records are available over this period. In the present analysis the first and last films of the series have been traced on both the normal and the abnormal sides. From the tracings it is hoped to obtain information about the amount of growth on both sides of the face, using the normal sides as some sort of control, as there are not any records available of untreated cases of comparable ages.

The Measurements (*Figs*. 8, 9)

1. Middle-third height. The perpendicular distance from the line SNa to the anterior buccal cusp of the upper first permanent molar.
2. The mandibular molar height. The perpendicular height from the mandibular plane to the anterior buccal cusp of the lower first permanent molar.
3. Total face height. The sum of the above two measurements.
4. Changes in centre line.
5. Changes in occlusal plane levels.
6. Bone remodelling.

Interpretation

The measurements taken from the first tracings are subtracted from those of the second, in order to obtain the gains in height in maxilla and mandible.

Maxillary Height Increases (*Table I*)

Table I shows maxillary measurements in two acquired and two congenital cases.

greater. The ankylosis was not freed until the two bone grafts had been inserted. Compared with *Case* S.J., there was not much difference in the amount of growth on the affected sides, but because the ankylosis was allowed to persist in *Case* F.B. the normal side growth was also restricted. Consequently, the comparative gain of the affected side is greater. In addition, as *Case* S.J. was not ankylosed, more

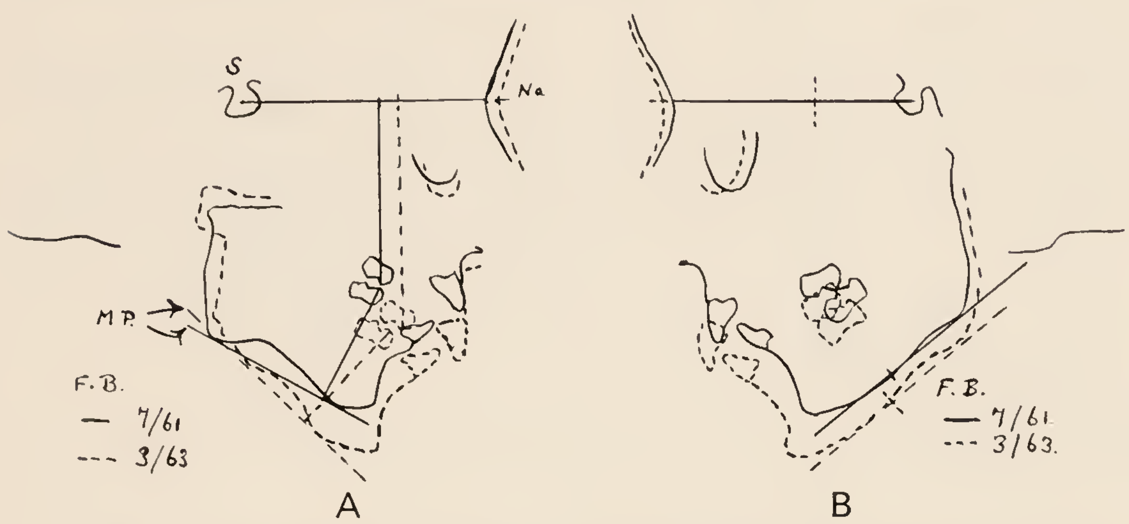


Fig. 8.—*Case* F.B. Acquired. A, Method of measuring vertical height of upper and lower molars by perpendiculars from SNa and MP respectively. B, Normal side. The origin of the SNa perpendicular is the same in both cases. Note absorption of gonial prominence.

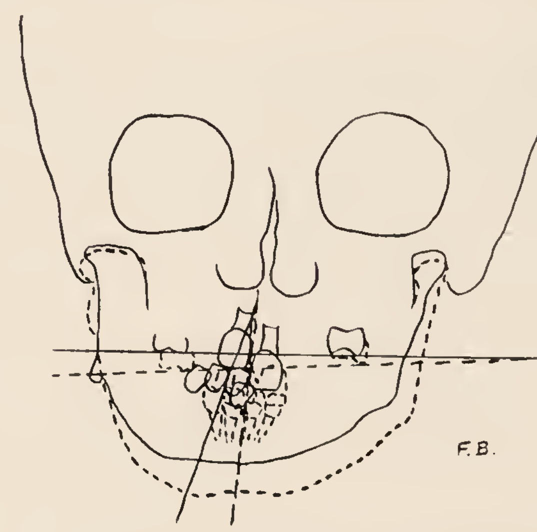


Fig. 9.—*Case* F.B. Same dates as in *Fig.* 8. Note the drop of the occlusal plane on the affected side and inward movement of the upper molar. The centre line and lower incisor lean have been corrected.

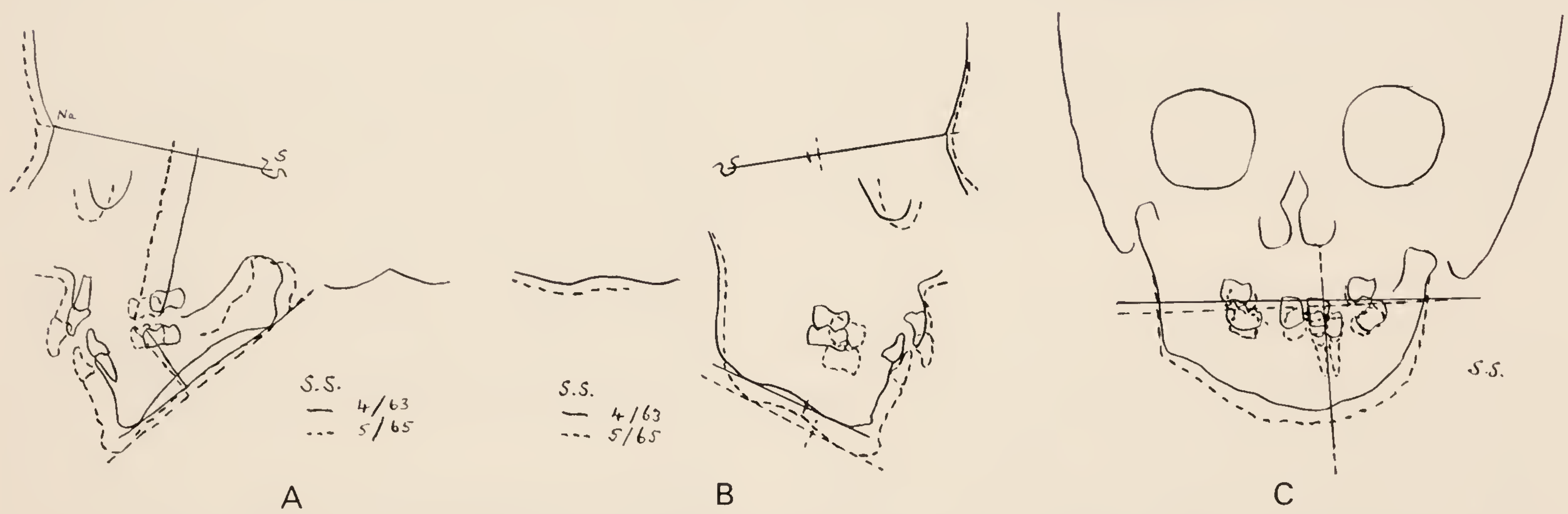


Fig. 10.—*Case* S.S. Congenital. A, Small amount of vertical growth of the affected maxilla but good forward growth. B, Normal side with normal growth pattern. C, Shows increased tilt of the occlusal plane. No improvement of centre line.

It will be seen that in all but one case the agenesis side has gained more height than the normal side over the same length of time. The postero-anterior tracing of one of the cases (*Case* F.B.), shows how this induced differential in growth rate has the effect of levelling the disturbed occlusal plane (*Fig.* 9). In the congenital case (*Case* S.S.), the occlusal plane will have become more tilted and this is borne out by clinical observation (*Fig.* 10). *Case* F.B. was a severe example of acquired agenesis and was ankylosed on the affected side, consequently the disturbance to growth on the affected side was

growth was possible on the affected side than in *Case* F.B.

Of the two congenital cases *Case* A.F. had a functional, although deformed, condyle head and the congenital defects as they affect the middle third of the face are less severe than in *Case* S.S., in whom there was no temporomandibular joint, the ramus of the mandible finishing just above the level of the lingula. The poor growth response of the maxilla in *Case* S.S. indicates that it has been more involved in the congenital disturbance than has the maxilla in *Case* A.F. The growth response of the latter is not much below the level

of the acquired cases and the postero-anterior tracing shows a good levelling of the occlusal plane (*Fig.* 11).

Mandibular Measurements (*Table II*)

With one exception, a consistent pattern of change is shown by the mandibular measurements. The normal sides may be considered to all

the mucoperiosteum at the time of the first bone-graft. Although the crowns of both teeth have appeared, they have obviously done so by differing mechanisms. The increase in height of 10 mm. in *Case* S.S. can only have been achieved by active alveolar growth, whereas the crown in *Case* S.J. must have been uncovered by a peeling back of the mucoperiosteum, since no measur-

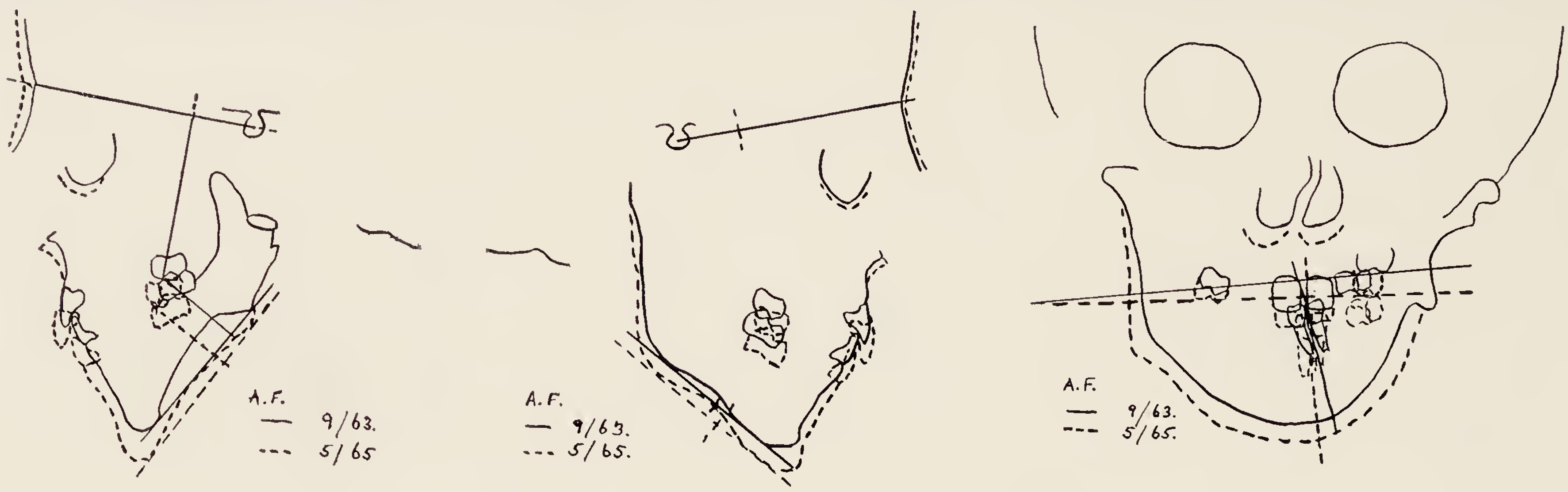


Fig. 11.—*Case* A.F. Congenital. A, Affected side. Normal growth response (c.f. *Case* S.S. *Fig.* 10). B, Normal side. C, Good correction of occlusal plane and uprighting of the lower incisors.

exhibit an equal amount of vertical growth. On the affected side in the acquired cases, no measurable growth has occurred, but in the worst of the congenital cases, a considerable increase has

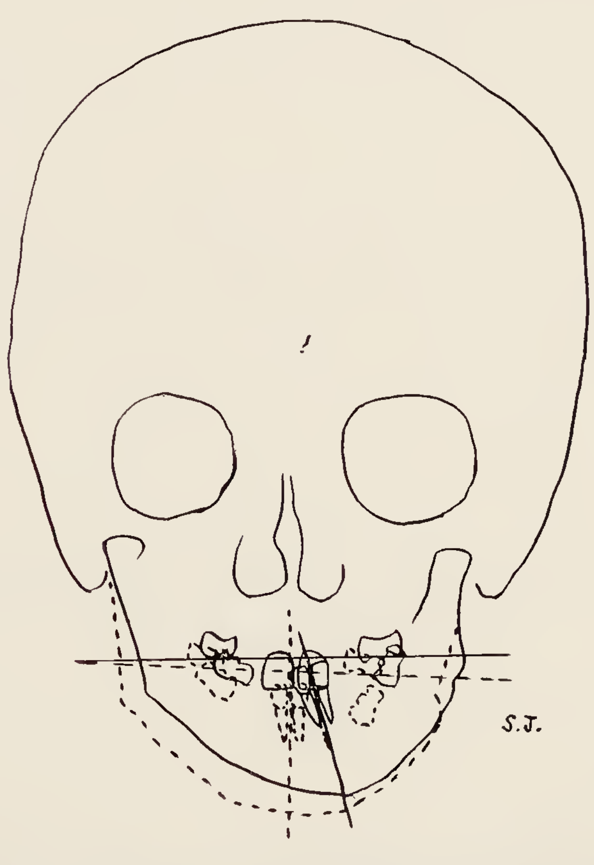


Fig. 12.—*Case* S.J. Acquired. Note: (a) The correction of the centre line; (b) Levelling of the occlusal plane. (c) The lateral movement of the upper molars towards the normal side.

occurred. The acquired case (*Case* S.J.; *Fig.* 7 B) and the congenital case (*Case* S.S.; *Fig.* 10 A) may now be compared, since in both of them the first permenant molar was just showing through

able increase in height has taken place. Furthermore, the upper molar in *Case* S.J. grew down rapidly to fill in the posterior open bite created by the bone-graft elongating the ramus, whereas very

Table I.—Maxillary Height Increases

Case	*Normal*	*Agenesis*	*Agenesis Gain over Normal*
S.S.(c)	6 mm.	4·5 mm.	−1·5 mm.
A.F.(c)	4·5 mm.	8 mm.	3·5 mm.
S.J.(a)	8 mm.	11 mm.	3 mm.
F.B.(a)	6 mm.	12·5 mm.	6·5 mm.

(c)=congenital; (a)=acquired

Table II.—Mandibular Height Increases

Case	*Normal*	*Agenesis*	*Agenesis Difference from Normal*
S.S.(c)	3 mm.	10 mm.	7 mm.
A.F.(c)	2 mm.	1 mm.	−1 mm.
S.J.(a)	4·5 mm.	0 mm.	−4·5 mm.
F.B.(a)	3 mm.	0 mm.	−3 mm.

(c)=congenital; (a)=acquired

little maxillary growth took place in *Case* S.S. and the mandibular alveolus was able to carry the molar upwards into occlusion.

Total Face Height Increase

The result of these measurements is to give the overall effect upon the whole face, and *Table III*

shows that in three of the cases the agenesis side has gained over the normal.

In the case of S.J., the normal side has shown rather more increase than the other cases, and this difference is probably due to two reasons:—

1. The child may have been growing at a greater rate than the others in the series.

2. The time interval between the tracings is a little longer in this case.

Changes in Centre Line

When the two congenital cases (*Case* S.S. and *Case* A.F.) (*Figs.* 10 and 11), are compared with the two acquired ones, it is apparent that correction of the centre lines may be more successfully achieved in the acquired condition. Of the congenitals, *Case* S.S. has no fixed joint on the affected side, so that there was nothing to stop the foreshortened ramus swinging quickly over to the affected side. In *Case* A.F. (*Fig.* 11) there was not much deviation of the centre line preoperatively, so that correction in the vertical plane was more important in this case. As far as the acquired cases are concerned, the nature of the original lesion will give rise to a greater degree of asymmetry, but this will depend upon the extent of the destruction of the growing cartilage of the condyle head. *Case* F.B. (*Fig.* 9) had ankylosis on the affected side and her two bone-grafts were inserted before the condylectomy was performed. *Case* S.J. (*Fig.* 12) also had apparently complete loss of the condyle head, so that her degree of asymmetry was severe. In three other cases which have come under our care, all of them acquired, the asymmetry is of equal severity. These cases have not been under treatment for a sufficient length of time to be included in the present preliminary report.

Changes in Occlusal Plane Levels

Table I indicates that a change in occlusal level should be found in three of the cases. The postero-anterior tracings serve to indicate that a change has occurred, but such films are not reliable as a means of measuring the amount of such change, because the slightest variation in the alinement of the Frankfurt plane in the head-holder, leads to considerable difference in the images of the points of superimposition, such as the orbital rims and the nasal cavities. In addition to the obvious changes in occlusal level to the benefit of the agenesis side in *Cases* A.F., S.J., and F.B., the failure to obtain any improvement in *Case* S.S. is shown. Study of the post-operative outlines of the upper molars shows that they have followed the mandible in its swing to the normal side (*Figs.* 9, 11, and 12).

Bony Remodelling (*Fig.* 11)

A certain amount of remodelling takes place, affecting chiefly the exaggerated insertion process for the masseter and the internal pterygoid. There also seems to be some tendency to fill in along the lower border in front of the masseter insertion. The resorption of the angle of the mandible will be related to the alteration in the site of the insertion of the muscles, to a higher position, following the elongation of the ramus. A similar resorption is seen following osteotomy of the ramus in the treatment of prognathism when the stripped muscles find their insertion further forwards.

Table III.—Total Face Height Increases

Case	*Normal*	*Agenesis*	*Agenesis Gain over Normal*	*Time Interval*
S.S.(c)	9 mm.	14·5 mm.	3·5 mm.	26 months
A.F.(c)	6·5 mm.	9 mm.	2·5 mm.	20 months
S.J.(a)	12·5 mm.	11 mm.	−1·5 mm.	28 months
F.B.(a)	9 mm.	12·5 mm.	3·5 mm.	20 months

(c) = congenital; (a) = acquired

GENERAL CONCLUSIONS

The number of cases presented is too small to allow any firm conclusions to be reached. One may safely say, however, that it is possible to induce some degree of extra growth of the under-developed maxilla in cases of unilateral agenesis, whether of acquired or of congenital origin. Judging from the single case (*Case* S.S.), where no established joint was present, it would seem essential for the success of the technique that the affected side should be buttressed by some sort of firm joint, albeit a false one, formed following osteomyelitis of the condyle head. The acquired condition is a much more localized disturbance, but with secondary effects upon the maxilla of the affected side. There are indications that the operative technique employed, that is serial bone grafting, may go some way to allowing normal maxillary growth to be resumed. In the congenital ‘ first arch syndrome ’, the extent of what Greer Walker calls ‘ intra-uterine necrosis ’, varies considerably, but the reduced outer canthus-external auditory meatus distance seems to be a

constant feature. Although it has been indicated that some restoration of vertical symmetry may be achieved, and even some correction of the mandibular centre line, no operative procedure can completely replace the missing structures. Compared with the acquired condition, where only bone needs to be replaced, the congenital asymmetry suffers from deficiency of soft tissues also, and mention has been made of the absence of the masseter and even of the inferior dental bundle in one case. Nevertheless, the limited improvements possible should not be regarded as a contra-indication to treatment.

There is no doubt that the closest collaboration between the orthodontist and plastic surgeon, in planning and performing these operations, is vital to their success and for learning as much as possible about the conditions and their treatment.

Acknowledgements

I am particularly fortunate in being able to work in close association with my Plastic Surgery colleagues, Mr. R. P. Osborne and Mr. A. H. M. Littlewood. I am also greatly indebted to the skill of Mr. Alan Orritt, Maxillo-facial Technician at Alder Hey Children's Hospital, to Mr. M. Bayliss, Medical Photographer at Whiston Hospital and the Librarian of the British Dental Association.

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THE POSTNATAL PATTERN OF GROWTH AT THE SUTURES OF THE HUMAN SKULL

AN HISTOLOGICAL SURVEY

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OUR knowledge of the facial sutures in man remains insufficient for any useful evaluation of their overall role in facial growth. On the other hand, the growth activity at the sutural margins of the cranial vault bones in foetal life and early childhood appears to have been adequately demonstrated (Giblin and Alley, 1942; Baer, 1954).

In man, evidence for the contribution by the sutures to facial growth is mainly circumstantial. The growth phase extends over two decades and a characteristic of the human skull is that the majority of sutures persist until after this time. However, persistence does not necessarily imply activity. In support of the sutural theory it is stated that the facial sutures in profile are so orientated that growth in them would displace the upper jaw downward and forward (Weinmann and Sicher, 1955). Furthermore, it is generally accepted that anteroposterior growth of the face conforms to a steady downward and forward pattern (Broadbent, 1937; Brodie, 1941). In a critical analysis using metallic implants as markers, Gans and Sarnat (1951) showed that facial growth in the young monkey was accompanied by growth at the zygomatico-temporal suture, but that new bone formation at the circum-maxillary sutures was surprisingly less, over a 10-month period.

In the case of the human, numerous studies on foetal and neonatal material have indicated that the facial sutures are actively growing sites during this period, but the suggestion of a continued role in postnatal growth would appear to rest heavily on extrapolation from these findings and upon analogy with the sutures of the cranial vault. While growth at the sutures of the skull vault seems to be related to expansion of the brain, it is not so obvious that the facial sutures are related to any similar kind of expansile force. Scott (1953; 1954) has suggested that the nasal septum is largely responsible for the downward and forward growth of the maxillae until about the seventh year, and that the growing orbital structures provide a stimulus to growth at the orbital sutures.

When the individual skull bones become more firmly united in early childhood as the deciduous dentition is established, a rationale for growth at a given facial suture becomes more difficult to accept. If, in postnatal life, the nasal septum, expanding orbital contents, or any other agency, effects a sutural response, then, at best, the processes are little understood. Since some clarification of the role of a suture in skull growth is possible when its histological character is known (Pritchard, Scott, and Girgis, 1956), it was decided to investigate the structure of a number of sutures in the human skull over the postnatal growing period.

MATERIALS AND METHODS

A total of 80 sutures representing an age range of from birth to 18 years were studied. These included specimens of the coronal, sagittal, squamous temporal, zygomatico-maxillary, pterygo-palatine, median palatal, and the transverse palatal sutures. This material was trephined from autopsy cases in which the skeletal system was relatively unaffected by the manner of death. The number of specimens obtained of a particular site at different ages varied from 12 of the mid-palatal suture to 3 of the zygomatico-maxillary suture. All specimens were fixed in 10 per cent buffered formalin, decalcified in 10 per cent formic acid aided by a cation exchange resin, and embedded by the double-embedding technique in 5 per cent low-viscosity nitrocellulose and paraffin wax. In the case of the cranial and palatal sutures sufficient representative transverse sections were cut on a rotary microtome

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set at 10 μ to permit some appraisal of structural variation due to the interlocking spurs of bone.

Serial sections were cut of the zygomatico-maxillary and the pterygo-palatine sutures, and were mounted at 50-section intervals so that the histological pattern throughout the whole suture could be studied. The zygomatico-maxillary suture was cut in a plane at right-angles to its long mediolateral axis and the pterygo-palatine suture was sectioned in the horizontal plane. Masson's trichrome stain and haematoxylin and eosin were used to stain the younger material, complemented by Van Gieson's stain for older tissues.

Fig. 1.—The sagittal suture at 3 years and 10 months. Closer union of bones is indicated by interlocking of bones and narrowing of sutural width.

Fig. 2.—A higher magnification of the suture in *Fig.* 1. Osteoblasts on the bone margins are reduced in number; there is a generally more fibrous structure. (× 98.)

For comparison with the normal palate, comparable sections were prepared from a 9-month-old case of arrhinencephaly with nasal septum and premaxillary agenesis.

RESULTS

Cranial Vault Sutures

Shortly after birth it was evident whether the developing suture would be of a basically squamous type, as in the parietotemporal, or have an edge-to-edge relationship as in the sagittal suture. The bone margins were separated by a relatively wide fibrous zone composed of parallel fibres which coursed directly from one bone margin to the other, blending with the outer pericranium and the inner dura mater. The cellular appearance at the bone margins was characteristic of rapid osteogenesis.

At the end of the first year much narrowing of these sutures had occurred, but they were still relatively wide and associated with marked bone apposition at the bone margins. The coronal suture in one case at 6 months had assumed an interlocking cross-section, but a 2-year-old specimen still showed a simple overlap relationship. Thereafter, interlocking spurs were a constant feature of the cross-sectional structure. Interlocking was first seen in the sagittal suture at 3 years and 10 months (*Fig.* 1). The parieto-temporal suture remained a simple squamous structure.

Judging from the cell densities of the osteoblast and pro-osteoblast zones it was clear that there was some diminution of osteogenic activity after the first year; by 2 years it appeared that growth activity was considerably reduced and at 3 years and 10 months it seemed negligible in amount (*Fig.* 2). This was so in all three skull vault sutures studied. In older specimens the processes of bone thickening and interlocking continued with the fibre bundles becoming more pronounced and tending to course directly across the suture.

The Palate

The suture between the palatal processes of the maxillary bones was studied at a site just anterior to the transverse palatal suture (palato-maxillary). At birth the median palatal suture was clearly a site of active growth. The vomer was interposed so as to contribute to the upper half of the suture. The bone of the palate was finely cancellous throughout (*Fig.* 3). Probably the most striking feature was the obvious apposition of bone on the oral surface and resorption on the nasal surface. At 6 months the median palatal region looked more mature, the palatal processes of the maxillae showed progress towards a cortical and medullary structure, and the vomer had a very consolidated appearance in an extensive medullary cavity and compact cortical bone. Activity in the suture appeared to be slightly less than at birth and contrasted very much with the impression of greater osteogenic activity along the oral surface. The latter was associated with osteoclasts along the nasal floor and the lower endosteal surfaces (*Fig.* 4).

This mechanism of downward remodelling of the hard palate was so striking in the neonatal

period as to prompt enquiry into when it began in foetal life. Examination of a series of foetal specimens showed that it was active at 16 weeks and was a constant feature thereafter.

Fig. 3.—Median palatal suture at birth. The palatal bone is finely cancellous and osteogenesis is active in the suture and on the oral surfaces.

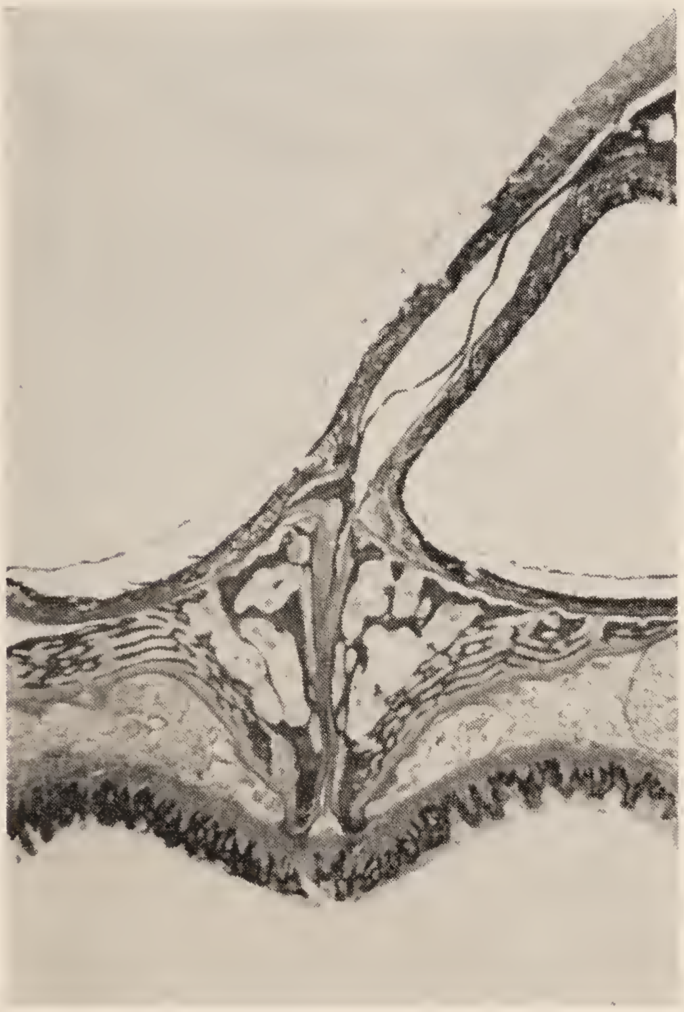

Fig. 5.—Median palatal suture at 2 years and 2 months. Sutural activity is much reduced. Marked oral surface apposition is indicated by fine parallel trabeculae of bone, contrasting with upper nasal surface.

At 2 years the median maxillary suture showed a very noticeable contrast with younger specimens in the intervening tissues. The suture was narrower, fibre bundles coursed parallel to the bone margins, and the number of cells comprising the cambial zone was much reduced. Osteogenesis in the suture appeared to be very much reduced, but the pattern of oral apposition and nasal resorption was a marked feature in this specimen, being clearly visible under low power due to the fine parallel trabeculae of bone on the oral side and the contrasting irregular nasal

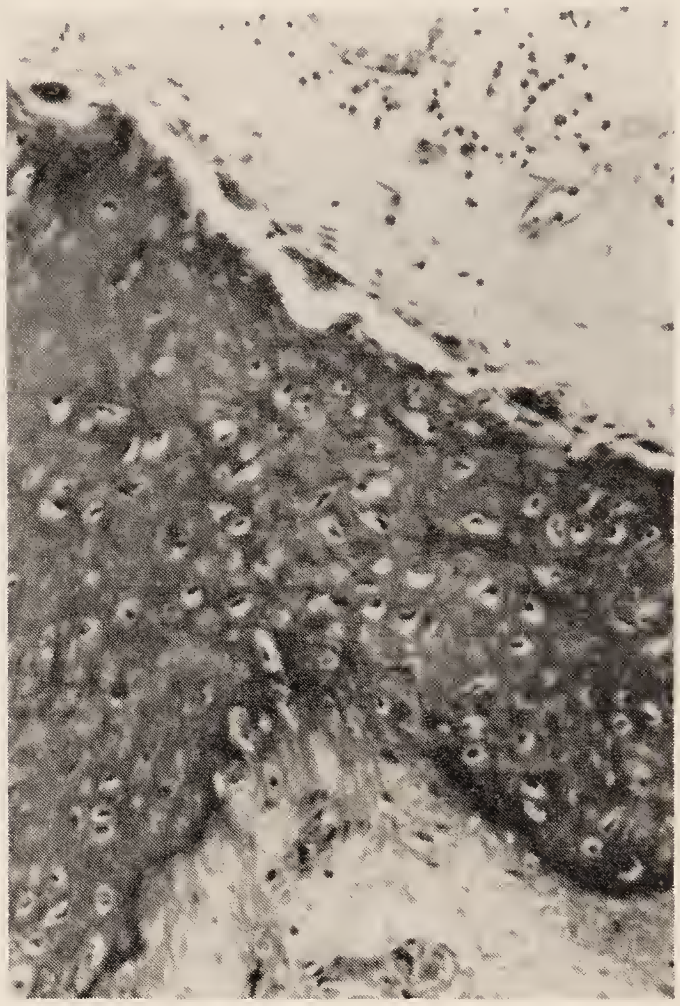

Fig. 4.—Photomicrograph illustrating downward remodelling of the palatal bone with oral surface apposition and endosteal resorption. (× 160.)

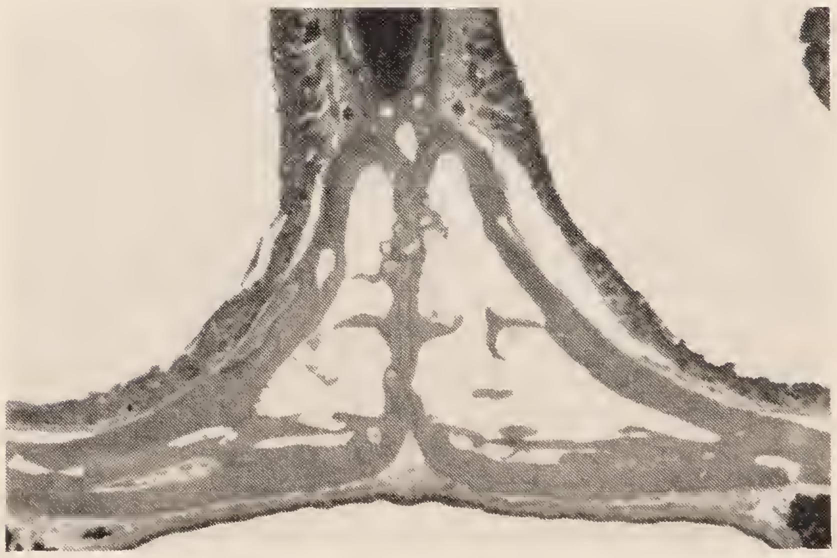

Fig. 6.—Median palatal suture at 3 years and 10 months. This consolidated and quiescent structure of the suture is characteristic from 3 years onwards.

cortex (*Fig.* 5). At 3 years the median maxillary area presented a consolidated appearance with a quiescent suture and a distinct cortical and medullary structure in the medial ends of the palatal processes. The oral apposition of bone now appeared to be much less but still in evidence.

In all older specimens there was a similar structure indicating a quiescent state of the

suture. At 15 years the bone was still appositional in character on the oral surface, the nasal surface resorptive, and the overall appearance was of thicker and more compact bone (*Fig*. 6).

It was of great interest to examine sections of the palate from the arrhinencephalic specimen in which the nasal septum was congenitally

Fig. 7.—Median palatal suture from a 9-month-old arrhinencephalic. The nasal septum is absent but the normal mechanism of nasal resorption and oral apposition is apparently unaffected.

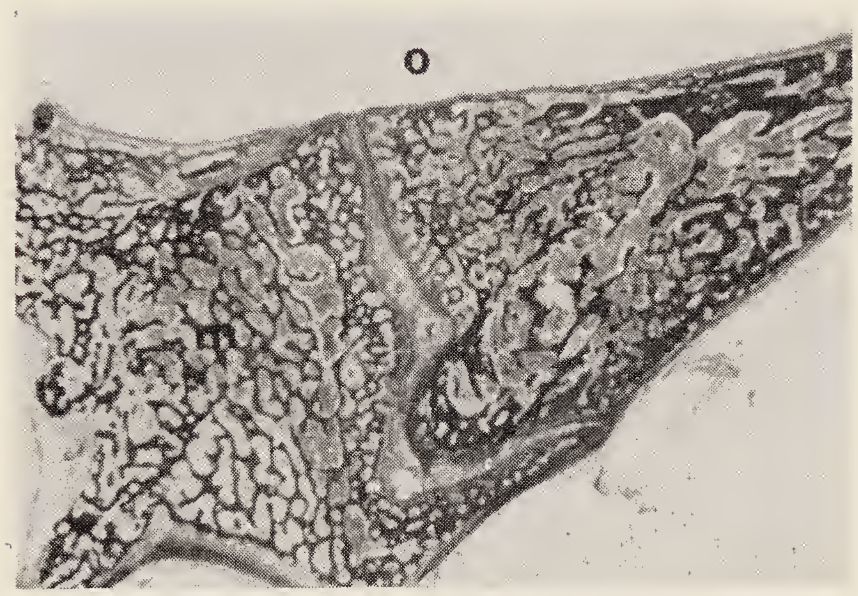

Fig. 8.—Zygomatico-maxillary suture at birth. Both bones are finely cancellous and active growth is apparent on the sutural margins. m, maxilla; z, zygomatic bone; o, orbit.

absent (*Fig*. 7). Surprisingly the same pattern of oral apposition and nasal resorption was found, and it may be noted that the height of the nasal region was not greatly affected. However, the anterior-posterior dimension of the middle third of the face was clearly deficient.

The Circum-maxillary Sutures

The zygomatico-maxillary suture leaves the orbital floor at right-angles, is quite straight in its upper half, and then bends through an acute angle to reach the facial surface. This relationship of the zygomatic and maxillary bones is present when the suture first forms in foetal life and seems to be preserved throughout postnatal life. At birth the bone margins were in close approximation and the five basic layers of the intervening connective tissues described by Pritchard and others (1956) were present (*Fig*. 8). There were obvious indications of growth on both sides of the suture which gave rise to an evenly cancellous margin to the maxillary bone and upper part of the zygomatic bone. The lower part of the zygomatic bone margin appeared to be older bone where it made a tongue and groove formation. The orbital and facial surfaces of the maxilla and zygomatic bone were appositional in structure, but more noticeably so on the alveolar process of the maxilla. Osteoclasts were present on the walls of the tooth crypts.

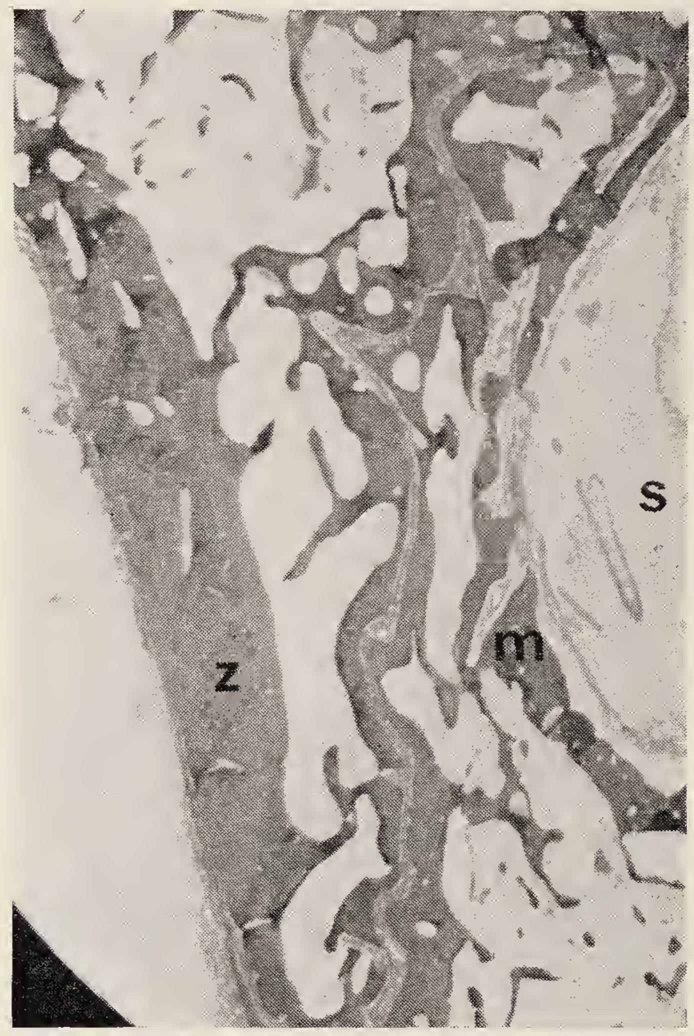

Fig. 9.—Zygomatico-maxillary suture at 8 years. The suture is narrow and highly fibrous with little evidence of general bone formation. z, zygomatic bone; m, maxilla; s maxillary sinus.

At 8 years the contour of the sutural interface was similar to that seen at birth. The width of the suture was very much less and the bone margins were of uniformly narrow cortical bone, in contrast to the woven bone structure seen at birth (*Fig*. 9). On the maxillary side the medullary cavity was reduced towards the sutural region by the maxillary sinus, which was actively expanding. The zygomatic bone had a mature, well-formed cortex and medulla. The sutural margins of both bones showed variable incremental lines, but, taken with the highly fibrous structure of the intervening tissue, it appeared that any bone apposition in the suture at this age must have been of low grade and perhaps

concerned more with internal structural remodelling, and correlated with the expanding maxillary sinus.

In an 11-year-old specimen the zygomatico-maxillary region was more mature, as judged by the compactly formed cortex and extensive medullary space of the zygomatic bone and the larger maxillary sinus. The bone margins were appositional in character with osteogenic activity being of low intensity.

Pterygo-palatine Region

At birth a sagittal section showed that the posterior region of the maxilla was composed of posteriorly radiating trabeculae of bone, similar to the radiating spicules which are characteristic of developing cranial bones. Clearly the greater part of the maxillary bone posterior to the canine position had been formed by growth on the posterior surface (*Fig.* 10). The palatine bone was related to the medial surface of the maxilla and did not appear to be directly involved in this posterior maxillary growth. This site of maxillary growth can be regarded as important throughout foetal life and probably for some time during the first year of postnatal life.

At 8 years a horizontal section through the posterior alveolar region showed a generally mature condition of the bone with well-formed medullary spaces (*Fig.* 11). The bone forming the crypts of the developing permanent second and third molars was finely cancellous and presumably in a state of constant remodelling. Incremental lines were present on the posterior wall of the maxilla and these were associated with signs of resorption on the adjacent endosteal surface. The palato-maxillary suture, here complicated by interlocking spurs of bone, showed a pattern of remodelling which suggested a forward pressure by the maxilla on the palatine bone.

Fig. 10.—A sagittal section of the pterygo-palato-maxillary region at birth. The posteriorly radiating trabeculae of the maxilla indicate the extent of posterior growth. m, maxilla; pl, palatine bone; p, medial pterygoid plate.

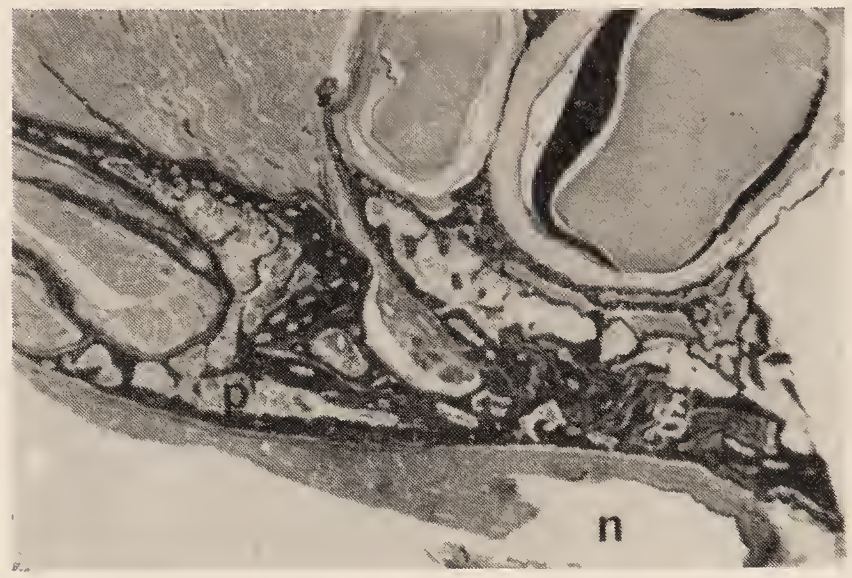

Fig. 11.—A horizontal section of the pterygo-palato-maxillary region at 8 years. The bone is generally mature in type but remodelling is evident in the palato-maxillary suture (S), and adjacent to the permanent second and third molar tooth germs. p, pterygoid plates; n, nasal cavity.

Fig. 12.—Diagram illustrating the growth pattern of the maxilla at birth as seen in a coronal section.

Sections above the level of the teeth included the maxillary sinus which still had not quite reached the posterior maxillary wall. An interesting area of fine cancellous bone appeared to be localized to the former position of the third molar tooth germ. The posterior wall at this higher level, i.e., related to the pterygo-palatine fossa, was appositional or static in nature, covered with a periosteum which was characteristic of very slow osteogenesis.

At 11 years a horizontal section of the posterior maxillary region was much more advanced towards the adult bone structure in that the maxillary sinus now extended to the posterior maxillary wall which was a thin plate of bone. The wide pterygo-palatine fossa observed in younger specimens was now considerably eliminated by approximation of the posterior maxillary surface to the pterygoid plates.

Growth indications were the same as in the 8-year-old specimen, i.e., low-grade apposition posteriorly and resorption on the maxillary sinus wall. Resorption on the lateral wall of the nasal cavity was a constant finding. A conspicuous feature of this older specimen was the remodelling posteriorly of the pterygoid plates. The forward facing surfaces were resorptive in appearance and the posterior surfaces were appositional in nature.

In examining material such as this it was clear that observations could only be qualitative in nature, for, in view of the problem of whether the dental arch increases in length by posterior or anterior growth, it would be important to have some quantitative assessment of bone apposition at a growth site. *Fig.* 12 illustrates a summation of the observations on material at birth as seen in a coronal section. Growth occurred mainly on the oral surface of the palate, at the median palatal suture, on the alveolar processes, on the facial surface, and in the zygomatico-maxillary suture. The floor of the orbit was appositional in character but of less intensity. Resorption occurred on the entire nasal surface and in the crypts of the expanding tooth germs.

At 8 and 11 years, except for the quiescent sutures and the different dental condition, the evidence was that, in general, the pattern of bone formation seen at birth was recognized. The contribution of the circum-maxillary sutures was apparently negligible, but it was always difficult to distinguish between a low rate of osteogenesis and an inactive state.

DISCUSSION

In view of the interest in the nasal septum as a major determinant of upper facial growth, it was indeed fortunate that a report could be included on the palate of a case of arrhinencephaly with nasal septum agenesis. A more thorough analysis of this valuable specimen is now being carried out. Surprisingly, as seen in a frontal radiograph, the nasal cavity was of considerable height and perhaps relatively normal in this respect. The palate was found to have the characteristically normal pattern of inferior surface growth and superior resorption. Clearly the mechanism of surface apposition played an important part in producing this nasal height and descent of the palate. Growth at the circum-maxillary sutures cannot be entirely discounted due to the influence of other environmental factors. It appears therefore that the nasal septum has a role in determining anteroposterior growth of the upper face, particularly in the early months of postnatal life, but it can scarcely be regarded as the *sine qua non* of vertical facial growth.

One is apt to become involved with the question of factors controlling osteogenesis at the facial sutures and overlook the fact that much dimensional change in the skull is possible by general surface accretion and internal remodelling. Indeed the three dimensional planes of the sutures of the face are such that adult proportions could conceivably be attained solely by this mechanism.

It is a little surprising to find that the sutures of the skull vault had decreased markedly in growth activity at the fourth year. Cessation of osteogenesis in the median palatal suture after the first year has been suggested by Scott (1955). However, one continues to find evidence of surface apposition and resorption in the vicinity of sutures, e.g., the squamous temporal suture was remodelling laterally, all the palatal sutures were remodelled downwards.

These observations appear to point to an early cessation of active growth in the sutures generally from the second year onward, but to continuing activity of the remodelling process and surface accretion. Although material for the zygomatico-maxillary and pterygo-palatine sutures was lacking between birth and 8 years, it now seems probable that these sutures cease to be sites of facial growth much earlier than 7 years, as suggested by Scott (1954).

The downward growth of the palate and maxillary alveolar processes from foetal life until maturity appears to be very much the result of surface apposition with corresponding enlargement of the nasal cavities and maxillary sinus. The histological evidence of the continuation of these processes after 2–3 years raises the question of how much growth at the circum-maxillary sutures is really necessary after this time to account for upper facial growth, and whether surface apposition and resorption is, in fact, the preferred mechanism of postnatal skull growth in general. The evidence suggests that after about 2–3 years of age the sutures function primarily as sites of fibrous union of the skull bones and growth changes thereafter are brought about mainly by the mechanism of surface apposition and remodelling.

In a recent paper it was reported that growth of the basi-sphenoid bone was accompanied by a relative backward and upward remodelling of the pituitary fossa (Latham, 1966). The roof and posterior parts of the orbital cavity have been found to undergo a similar upward and backward remodelling in postnatal life (Moss, 1955). The implication of this knowledge is mainly in the interpretation of radiographic cephalometric analyses of facial growth. It was mainly from such work that the concept developed of the ‘ downward and forward ’ growth of the upper face. This concept clearly led to a search within the facial region itself for the sites of this growth, and it seems probable that it was responsible in large measure for the prominence given to the circum-maxillary sutures as continuing postnatal growth sites.

It is clear that the demonstration of the amount of downward and forward facial growth was based upon the assumption of fixed reference points in the cranial base, of which the pituitary fossa (sella) was a principal one. Therefore, in so far as the pituitary fossa actually moves upward and backward in the opposite direction to the apparent facial growth vector, it seems that there is now a significantly less amount of growth to account for, at sites within the facial region. This study indicates that downward growth of the palate and alveolar processes is shared by both the mechanism of surface apposition and circum-maxillary sutural growth until about 2–3 years of age, but that thereafter growth may be accomplished mainly by surface accretion and associated remodelling.

SUMMARY

1. After the fourth year there appeared to be little growth activity in the cranial vault sutures, except for localized remodelling.

2. The median and transverse palatal sutures showed marked changes in structure during the first year of postnatal life and little evidence of growth after the second year.

3. The palate appeared to be remodelled downwards by surface apposition of bone and nasal floor resorption from the fourth month of foetal life until maturity.

4. The circum-maxillary sutures were sites of growth at birth and probably for the first 2 years after birth.

5. It appeared that after about 2–3 years the sutures of the skull in general functioned primarily as sites of union of the bones but localized suture remodelling was a continuing process.

6. The growth changes in the human skull after about 2–3 years of age, which hitherto have been interpreted in terms of a ' downward and forward ' concept of facial growth, appeared to be brought about mainly by downward growth of the maxillary alveolar and palatal processes, together with upward and backward growth of the sphenoid bone.

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RELATIONSHIP BETWEEN FACIAL GROWTH AND INCISOR OVERBITE

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This short investigation was undertaken with two objects in mind: to try out some methods for estimating dimensional changes taking place as a result of growth and thereby to discover whether, when changes in the vertical relationship of the incisor teeth were observed, these changes were or were not, on the whole, reflected in the growth of the face.

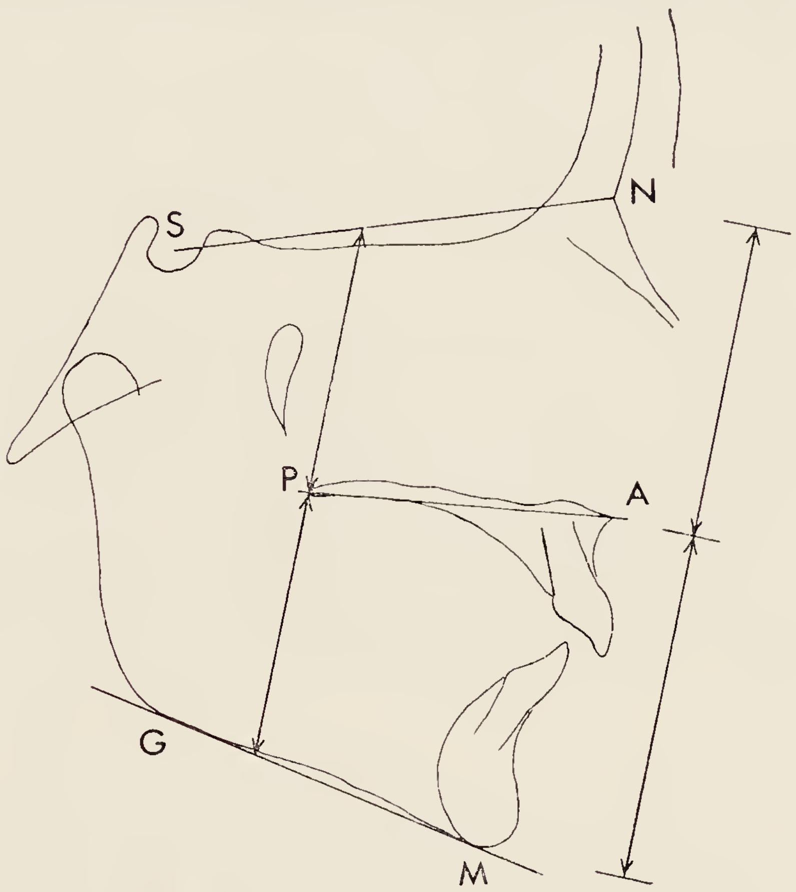

Fig. 1.—Facial heights were measured in planes parallel to the line nasion–menton. Posterior face height was measured through the posterior nasal spine P between the line SN and the mandibular plane. For the measurement of anterior face height, anterior nasal spine was projected on to SM.

The material available consisted of dental casts of a group of 220 children at mean age $5\frac{1}{2}$ years and again at mean age $9\frac{1}{2}$ years, and the corresponding lateral cephalometric X-ray films of the same subjects.

It was noticed on inspecting the casts at $5\frac{1}{2}$ years that 32 of the children had some degree of open bite or incomplete overbite, while at $9\frac{1}{2}$ years, of these subjects, only 22 had incomplete overbite. In 10 cases there was contact in the incisor region, the open bite had closed, and the incomplete overbite had become complete.

It is sometimes suggested that in infancy or early childhood the incisor relation is controlled by tongue and lip behaviour patterns, i.e., posture and function, and that subsequent changes in incisor relationship are determined by alteration in behaviour patterns. It was, therefore, decided to investigate the two groups of subjects, those in which open bite or incomplete overbite was present and became closed or complete, Group A, and those in which open bite or incomplete overbite remained, Group B, with a view to ascertaining whether there were any differences in the mode of growth of the face which might be related to the observed changes in incisor relation.

METHOD

The lateral skull cephalograms corresponding with the two groups of dental casts at $5\frac{1}{2}$ years and at $9\frac{1}{2}$ years were traced on to plastic tracing material, and three sets of measurements were made on these tracings (*Fig.* 1).

The measurements were:—

1. Anterior face height; total, upper, and lower measured between the projections of nasion, menton, and anterior nasal spine on to a plane parallel to NM.
2. Posterior face height; total, upper, and lower, measured in a plane parallel to nasion–menton between SN, posterior nasal spine, and mandibular plane.
3. The three available angular measurements between SN and maxillary and mandibular planes, SN/Mand., SN/Max., Max/Mand.

The measurements so obtained were used to ascertain whether there were any significant differences between the mean changes in these facial dimensions in Group A and Group B children.

Table I shows that, as might be expected, mean total face height, both anterior and posterior, increased in both groups, but it was found that the increase was greater in Group B than in

Presented at the Research Meeting held in Eastbourne on 19 May, 1966.

Group A. When face height is broken down into upper and lower, it is seen that the difference in increase between the two groups is all accounted for by increase in lower face height anteriorly and posteriorly. Lower anterior face height increased by 1·60 mm. more on the average in Group B than in Group A, and lower posterior face height by 0·8 mm. The difference in the increase between Group A and Group B in respect of the anterior dimension was statistically significant, but not in respect of the posterior dimension. It should be pointed out that the nature of the difference posteriorly was similar to that anteriorly, but if this difference posteriorly is in fact a real one, larger numbers of cases would be required to show that it was statistically significant.

The average angular changes are also interesting. In Group A in which the bite closed, the angle between mandible and the maxilla also closed by 2·50°, in Group B the reduction of the angle was only 0·5°. The difference between these changes is significant statistically. Average changes between SN and the maxilla and the mandible were found, but the two groups could not be said to differ in respect of these changes.

Table I.—Mean Changes in Facial Dimensions in Two Groups of Children between Ages of $5\frac{1}{2}$ and $9\frac{1}{2}$ Years

(In Group A, 10 children, incomplete or open incisor bite closed, in Group B, 22 children, incomplete or open bite remained.)

			A	B	Difference	SE Difference
Face height (mm.)	Anterior	Total	9·85	11·09	1·24	±0·79
		Upper	6·75	6·39	−0·36	±0·74
		Lower	3·10	4·70	1·60*	±0·62
	Posterior	Total	7·40	8·30	0·90	±0·68
		Upper	5·10	5·20	0·10	±0·67
		Lower	2·30	3·10	0·80	±0·58
Angular measures (degrees)		SN/Mand.	−1·10	0·30	1·40	±0·86
		SN/Max.	1·20	0·60	−0·60	±0·55
		Max./Mand.	−2·50	−0·50	2·00†	±0·72

* P=0·02−0·01

† P=0·01−0·005

DISCUSSION

This preliminary investigation brought out a number of difficulties connected with assessing growth changes and differences in growth patterns in the young child.

1. Obtaining accurate cephalometric records of young children presents special problems since when volunteer subjects are used, restrictions imposed on cephalometric technique may make it difficult to obtain the best possible film record, and also some very young children may not be fully co-operative in obtaining the films.

2. The present investigation has not yet been subjected to scrutiny as regards accuracy of measurement method. It is possible that variations within the method may obscure differences which actually exist or suggest differences which do not exist.

3. Division of material on the basis of a clinical criterion is not always as easy as might at first appear. There are always certain cases which might fall on one side or the other of the dividing line. The effect of chance in dividing up such material would need to be investigated. The only other alternative is to claim infallibility of judgement in the matter; but it is probably not good practice to do so.

4. The problem of obtaining adequate numbers of cases of exactly the right kind is an ever-present difficulty.

CONCLUSIONS

An investigation into facial growth changes associated with changes in incisor overbite relation has been carried out. A number of problems connected with obtaining accurate records and measurements of small children have been mentioned. The results of the investigation suggest that vertical growth changes in facial pattern are associated with changes in overbite relationship between $5\frac{1}{2}$ years and $9\frac{1}{2}$ years of age.

Acknowledgements.—The author is indebted to the Northern Ireland Hospitals Authority and the Medical Research Council for financial support, and to the Belfast School Medical and Dental Services, for assistance in obtaining the material upon which the investigation is based.

AN INVESTIGATION INTO LINGUAL SENSORY MOTOR SKILLS IN CHILDREN AND ADULTS WITH NORMAL SPEECH

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THE present investigation is the first stage of an attempt to produce a valid and reliable measure of an individual's lingual sensory/motor capacities. Such a measuring device might prove of practical advantage in the differential diagnosis of certain disorders of speech as well as providing a new type of treatment for oral minimal motor dysfunction.

LINGUAL SHAPE DISCRIMINATION TEST AND ASSEMBLY TASK

Adaptations of tests used by Grossman (1964), Tulley (1964), Grossman, Hattis, and Ringel (1965), and Berry and Mahood (1966) were employed in a shortened form. Five perspex shapes were presented for exploration by the tongue-tip and the subject was required to identify them on a chart showing ten line drawings in random order. The assembly task involved three trials in which the subject attempted to join two perspex matrices together in the mouth. This necessitated fitting a raised circular disk (diameter 8 mm.) on one piece into a corresponding hole in the other.

Results

One hundred and twenty-five children with the mean age of 14 years were tested. The scores of some of the groups indicated the highly significant relationship between the two tests.

In the largest group (65 secondary modern school boys) 60 per cent completed the assembly task in less than 10 seconds, and of these boys 71 per cent made not more than one error on shape discrimination. The mean time for the 65 boys was 10·4 seconds, with a standard deviation of 5·6. Some children required the full allowance of 25 seconds for the assembly task and made up to four errors on the shape discrimination.

MAGNITUDE DISCRIMINATION

A new test of lingual magnitude discrimination was employed with a group of 20 speech-therapy students. Four pairs of perspex disks were mounted at right-angles to interdental perspex bars and were presented for ten trials each in random order. The position of the variable stimulus was also randomized.

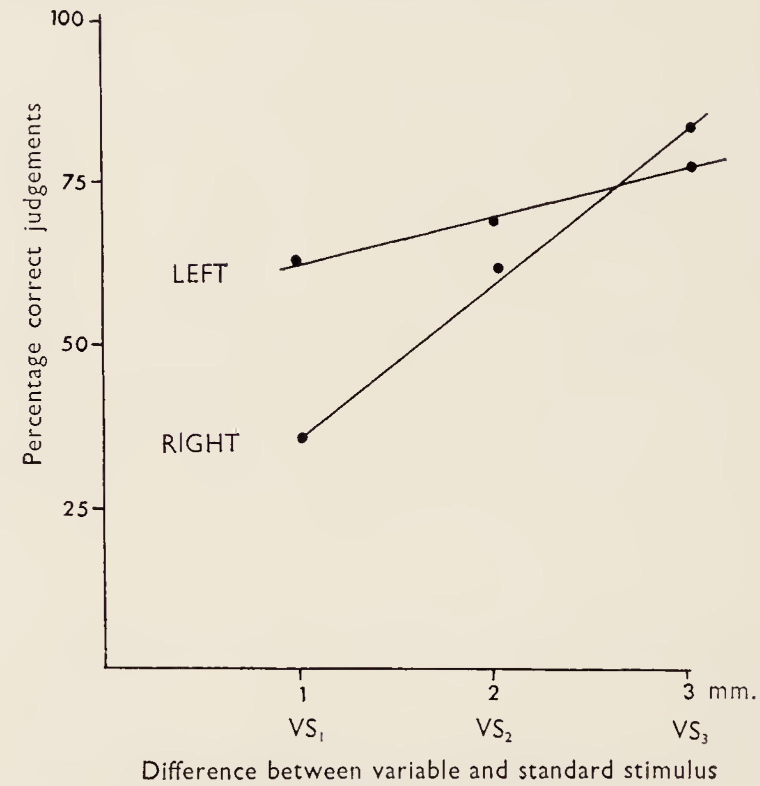

Fig. 1.—Magnitude discrimination test.

Results

Judgement on the first pair (VS1), where the difference in diameter was 1 mm. was shown to be significantly worse when the smaller disk was presented on the right side (*Fig.* 1). Exploration of a disk in this position requires contact with the left side of the tongue-tip. Correlated 't' test indicated that the difference was significant at the 1 per cent level (t = 5·43; D.F., 18).

Acknowledgements

I would like to thank Professor Tulley and his staff for their advice and patience, and Professor Emslie and Dr. Naylor for their co-operation and the facilities which they provided.

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SOME PSYCHOLOGICAL TECHNIQUES FOR CONTROLLING MOVEMENT

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It is the tradition in these memorial lectures to look at relations between orthodontics and neighbouring disciplines. George Northcroft himself carried out such an exercise most successfully when he brought together his own professional expertness and his love of archaeology, and by doing so was able to give a date to the remains of the Princes in the Tower. My own more modest task is to select some aspect of psychology which might be useful to orthodontists. I have decided to concentrate on the techniques of operant conditioning. These are well known among psychologists as means of controlling behaviour, but it is possible that the techniques will prove to be useful in controlling individual movements and even the activities of individual muscles. With some technical ingenuity operant conditioning might be used in the training of tongue and jaw movements.

OPERANT CONDITIONING

It is usual to associate the term 'conditioning' with the experiments of Pavlov, but there are several kinds of conditioning and operant conditioning is rather different from the Pavlovian variety. The term, and most of the techniques of operant conditioning, was invented by B. F. Skinner of Harvard University. Skinner has a restricted approach to psychology in that he is interested in the prediction and control of behaviour rather than in understanding it. A detailed description of his system, in the form of a programmed text, will be found in Holland and Skinner (1961), and a short, simple summary in Stretch (1966). For the purpose of this paper short descriptions follow of some of the main terms and techniques (the two are inseparable since Skinner always uses operational definitions). A *response* is any action produced by an organism. It is called a response even if there is no obvious stimulus causing it. If the response is followed by *reinforcement*, the response will tend to occur again and, if reinforcement is continued (but always contingent on the appearance of the response), then the response will be learned. Reinforcement is defined quite circularly as any event or stimulus which has just such an effect, so that reinforcers must always be discovered empirically. Some which usually work with animals are food (when hungry), drink (when thirsty), novelty (provided it is not frightening), and removal of noxious stimulation (for instance, switching off electric shock). With apes and monkeys a temporary view of the monkey colony, or hearing the noise of it, will act as reinforcement to an isolated animal. Humans can reinforce each other by means of agreement, smiling, praise, or even just attention.

In animal experiments the fundamental equipment is a box or cage, sometimes called a ' Skinner box ', which contains a device for delivering reinforcement, for instance a food trough. It may also contain a bar which a rat will be conditioned to press, or a disk which a pigeon will be conditioned to peck at, or some other device on which the animal can operate. Operating the device can be made to lead to reinforcement automatically, so that if an animal is left in the box it will eventually learn to make the required operation without any intervention from the experimenter. The *operant* (pressing the bar) will have become conditioned. (It is then possible to investigate the various factors which affect the strength of the habit which has been formed.) It is not, however, necessary to wait for the animal to produce the desired response by chance. Instead a technique known as *shaping behaviour* can be used. If it is desired to train a pigeon to turn twice in a circle, the pigeon is placed in the experimental cage and it learns very quickly that the click of the apparatus means that a pellet of food has been delivered in the food trough. (In fact the click becomes a *secondary reinforcer* and can act for a time as a reinforcer would, even if no food is presented.) In this case, the presentation of reinforcement is controlled manually by the trainer. When training starts, food is presented if the bird, in the course of its movements, makes what looks like the beginning of a turn; next it is reinforced only if it makes more of a turn; eventually it is reinforced only if its movements approximate more and more to the double circling which is required. By this shaping technique a pigeon can be trained in under 5 minutes. It is a technique which some animal trainers have used for centuries and which some parents use without

Twentieth Northcroft Memorial Lecture given at the Country Meeting held in Eastbourne on 20 May, 1966.

much awareness. What happens to the pigeon once it has been trained, or to the rat which has learned by trial and error, and without training, to press a lever, if the food is now no longer presented? The behaviour gradually extinguishes and the experimental procedure is known as *experimental extinction*. There may subsequently be occasional *spontaneous recovery* of the habit before it finally extinguishes altogether.

There are several different classes of reinforcer. Food to a hungry animal usually acts as a *positive* reinforcement; if the *operant* (response which is to be conditioned) leads to the termination of a noxious stimulus, this is *negative* reinforcement; if noxious stimulation results from the response being made, this is called, of course, *punishment*; also animals can be trained to press a lever, etc., so as to avoid a noxious stimulus, and this is one kind of *avoidance conditioning*.

Once the desired response has been learned, how can it be kept going? An animal will not work everlastingly for food nor will a human go on treating a smile as reinforcement. Both will satiate. In human conditioning it is difficult to find reinforcers for which the learner will not satiate. In fact in many cases the conditioning seems to fail if the learner is aware that he is being reinforced. In the techniques to be described later this fact may not be important. However, there are several ways of providing reinforcement which lead to very steady responding by the learner. One is to use avoidance conditioning, which is very resistant to extinction, but which often leads to considerable stress in the learner. A more useful technique is to use a variable *schedule of reinforcement*. Once the response has been learned, reinforcement is given not every time the response is made, but occasionally and irregularly, though of course, the reinforcement is still given only after a response. (These schedules are known as *variable ratio* or *aperiodic*, depending on the detailed method of administration). Under such schedules animals will produce very regular behaviour which is resistant to extinction (when reinforcement is withheld completely). Skinner argues that in everyday life most of one's reinforcements come irregularly and this would be expected to lead to fixed habits, in ordinary parlance. It is likely that people are so persistent in gambling, even when the rewards may be small, because the reinforcements occur on a variable schedule.

Skinner has demonstrated another way in which behaviour can be controlled by the environment. If an animal has been trained to perform an action for reinforcement when there is a light turned on, but when the light is off there is no reinforcement (extinction trials), the animal will come to work *only* when the light is on. The light has become a *discriminative stimulus*. It allows the animal to discriminate when some behaviour is appropriate (i.e., will be reinforced) and when it is not. (Perhaps this is one of the factors least put into practice in rearing children. It must be exceedingly difficult for children to discriminate between situations when noise and boisterousness will be acceptable, and when they will not be. There should be as many environmental cues as possible to make the discrimination easy.)

The three operant techniques of reinforcement, schedules, and discriminative stimuli have made it possible for Skinnerians to gain rather complete control of some aspects of an animal's behaviour. To what extent can these techniques be applied to humans?

OPERANT CONDITIONING OF HUMANS

Many of the human experiments have been little more than demonstrations that reinforcement techniques can be used to produce the same apparently automatic effects that are found with animals. It is claimed that some everyday behaviour, for instance the kinds of words one uses in talking, can be brought under control. Of course, if a person fails to respond, it can always be argued that the particular stimulus used was not an effective reinforcer for that individual! However, there are some rather convincing studies, particularly with children and infants. Brackbill (1958) has shown that it is possible to condition the smiling of babies, using smiling, etc., as reinforcement, and that the conditioning varies with the schedule of reinforcement; crying is usually reinforced by the attention of parents and there are several demonstrations that crying, which is not due to illness or discomfiture, can be extinguished in a lawful way by withdrawing attention; a highly distractable child, who was thought to be brain-damaged, was conditioned to attend in class by means of several kinds of reinforcement—sweets, counters, and social reinforcers in the form of encouragement from the rest of the class (Patterson, 1965); Baer (1962) has shown that thumb-sucking can be controlled in the laboratory by using cartoon films as reinforcement. The effect was temporary, but no attempt had been made to produce long-term improvement. However, this last case draws attention to the common finding that it is much easier to produce temporary changes. Several cases are discussed by Ullmann and Krasner (1965).

Control of Movements

Several American workers have applied operant techniques in attempts to control movements of muscle groups and individual muscles. One of the earliest studies (Hefferline, 1958) illustrates the technique, which is essentially one of *augmenting the feed-back*, which would normally be proprioceptive, from the muscle, presenting

this augmented feed-back to the subject, and reinforcing him for producing the required amount of feed-back. In the experiment quoted, Hefferline used the subjects' masseter muscle. By means of a simple form of electromyography, output from the muscle was presented to the subjects on a meter and they were reinforced for producing the desired meter readings. As in many of these experiments (Sasmor, 1966), the subjects knew that they were producing the meter readings, but did not know how they were doing it. In other experiments (Hefferline, Keenan, and Harford, 1959) muscles of the thenar eminence at the base of the thumb have been brought under control. In these experiments various kinds of positive reinforcement (e.g., money or simply building up a score) have been used, but there is some evidence that negative reinforcement is more effective, as would be expected. One form of this is to play the subjects music masked by noise. When the desired movement is produced, the noise is decreased.

Problems

In applying these techniques to movements, two kinds of problem arise. The first is the technological engineering problem of devising the apparatus which will produce augmented feed-back, or in some cases automatic reinforcement, from the movement to be controlled. (There is already a device on the market which claims to reduce tongue thrust by what seems to be the administration of a slight shock to the tongue. The mechanism is claimed to be Pavlovian, but in fact it is an example of punishment leading to avoidance conditioning of the operant.) It is conceivable that many branches of medicine and many kinds of therapist will find a use for these techniques and one can foresee there will be a place for what might be called ' operant engineers '—technicians who have a sound training in the techniques of operant conditioning.

The second problem is more formidable—how to use these techniques to establish permanent changes in movement. It is certain that improvements will be made by utilizing what is known about the effects of variable schedules and avoidance conditioning. In some cases, especially in behaviour therapy, results have been unsatisfactory for several reasons: the improvement in behaviour has been specific to the therapeutic situation because precautions have not been taken to make sure that it generalizes to other situations (the jargon way of saying this is that the therapist acts as a discriminative stimulus for the desired behaviour and, when he is not there, the behaviour extinguishes); or the *undesired* behaviour may be evidence for an underlying need or conflict which remains untouched by the operant technique. Obviously the most permanent change in behaviour is achieved if the new behaviour comes to be biologically and psychologically valuable to the learner. It is unlikely that the kinds of movement that orthodontists are interested in will express any deep needs or conflicts, and it would seem reasonable to attempt operant techniques without fear of finding ' symptom substitution '. It remains to find the methods which will produce the most permanent effects, so that frequent refresher courses are not necessary.

Other Applications of Operant Conditioning

Apart from its application to the control of movement, operant conditioning can give an interesting and entertaining way of looking at much of human behaviour. A dentist is of, course, a discriminative stimulus for his patient, but he plays a very mixed role. Before an extraction he is associated with anxiety and, as a result, his very appearance may promote anxiety; after the extraction he is associated with (negative) reinforcement—the removal of anxiety. The moral is that he should spend as little time as possible beforehand with the patient and as much as possible afterwards. George Northcroft must have known about these things. The anonymous writer of one of his obituaries records how he was in the middle of a difficult extraction in the old Dental Hospital in Leicester Square when Northcroft came in, took over, and completed the extraction speedily and efficiently. It is hard to think of a better way of ensuring that the patient has a positive attitude to the surgeon.

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DISCUSSION

Mr. J. S. Beresford asked what orthodontists could do if they had made an error of judgement; for example, if they had imagined that a child was happy and co-operative and omitted some of the preliminary pleasantries, and suddenly the child broke down and would have no more of them.

Professor Foss said that, supposing a child were allowed to go home and have no more to do with the dentist, it would be extremely reinforcing for the child because he had been taken away from a very anxious-making situation, and it would encourage a repetition of this.

Mr. A. J. Walpole Day asked Professor Foss how he would advise orthodontists to deal with cross-perception where the brain was not differentiated into right and left in the same way as in most normal people.

Professor Foss replied that there were several studies which suggested that there were ambidextrous people who had certainly no malfunctioning of any kind. There was another kind of person who was called ambigauche where there seemed to be instability as suggested, and there was quite a lot of evidence that in these people there was backwardness and also behaviour problems. Operant conditioning might be useful in some of these cases, but the programme would have to be developed specially for each child.

Mr. Walpole Day said that he was thinking more of behaviour problems, such as thumb-sucking, which might be a problem if one tried to reason with the children.

Professor Foss said he was glad this had been brought up because there was a word of warning he should give. The speaker probably thought if one tried to eliminate thumb-sucking the outcome might be worse than if it was left alone. Psycho-analysts had been saying for a long time that, if the symptom only was treated, any conflict which was basic to the symptom would remain. They would argue that to eliminate thumb-sucking in the way he had described might result in some other symptom replacing it which might be worse than the original. Most of the behaviour experiments he mentioned had not done enough to see if there were repercussions of this kind and it was important that this should be done in the future. In fact no repercussions had yet been noted. Thumb-sucking was self-reinforcing, very much in the way that smoking was, and the technique would be to find some substitute which did not damage the person.

Mr. D. Robertson Ritchie asked if Skinner's techniques had been used for the treatment of stuttering. Also he said that there was a system advertised for the treatment of enuresis whereby a magnetic field was set up, if the child caused the bed to become wet, which caused a bell to ring which wakened the child, and asked if this was the application of Skinner's technique.

Professor Foss said that the answer to the first question was no.* With regard to the second, there were several kinds of conditioning. This technique was invented by an American called Mowrer who based his theory on a mixture of Pavlov and Skinner. The technique was that, if the bed became wet, then an electrical contact was made and a bell rang and this woke the child. The way it worked was curious because it was a form of backward conditioning. What happened was that, although urination started before the bell rang, nevertheless the bell ringing became associated with feelings of a full bladder. The situation is more like Pavlovian conditioning. The bell did the waking up instead of the full bladder.

Mr. D. Robertson Ritchie asked if this could be applied to persuading a child to wear an oral screen.

Professor Foss said that he knew of no appropriate technique at present in use, but it should be possible to devise one.

Mr. N. L. Hill said that all the things Professor Foss had mentioned were arrangements whereby someone else was in control and not the patient. He said he was himself an inveterate cigarette smoker and asked if it was possible to use something on oneself?

Professor Foss replied that all the evidence was that one could not. If one was in control of the reinforcement oneself, the magic went.

Mr. E. K. Breakspear said that, as he understood it, these techniques were based on the logic of reward and punishment. What was the relation of this type of technique to that of suggestion and hypnosis, where he believed the idea of reward and punishment did not enter into it?

Professor Foss said that he found it difficult to see the connexion. Hypnosis and many kinds of suggestion led to what used to be called altered states of consciousness.

Mr. A. G. T. Allcorn said that most of the activities mentioned had been at a conscious level, such as eating. In a condition such as thumb-sucking, any correction on the lines of reward might be practicable during the day but what would be the position during sleep?

Professor Foss replied that in experiments on heart-beat control and also in the control of the finer muscle movement which he had described, the subject had not known what he was doing, although he knew he was controlling the situation. As far as he knew, sleep was a different matter and he did not know of anything that could be used during sleep.

Mr. G. C. Dickson asked, apart from the difference in terminology in Skinner's experiments and Pavlov's experiments, what was the fundamental difference between the two types of experiment?

Professor Foss replied that there were many kinds of conditioning and there were many criteria for distinction between them. In the Skinnerian kind the learner initiated the response himself, perhaps in response to something in the environment. He did something himself and his response had an outcome and that outcome was reinforcing. In the Pavlov situation a reinforcement in the shape of food was presented to the animal *before* he made a response. He made the response to the food in the form of saliva. If food was then presented along with a bell, he would eventually salivate when the bell went. In the Skinner setting the animal or person started the response and the environment provided an outcome. In the Pavlov situation environment started the thing going and the person or animal responded to the environment.

There were reasons for thinking that the two situations were different in many ways. The Skinnerian kind of conditioning was very rapid and could be done in front of a noisy class. Pavlov conditioning, in contrast, was slow and usually it was very important not to have distraction. In fact the original experiments were done in sound-proof rooms with the experimenter outside.

* There have been attempts, but with rather temporary effects in most cases.

THE ADAMS CEPHALOSTAT*

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THIS cephalostat has been designed with special regard to strength and rigidity combined with precision and ease of operation.

GENERAL FEATURES

Attention has been given in designing the unit to ensure long life and freedom from troubles arising during use. For instance it is impossible to force the earpost against the cassette holder accidentally or to raise the cassette holder against the rotary part of the cephalostat and so damage the moving parts.

The construction throughout is to high engineering standards and the finish is in stove enamel and satin chromium plating (*Fig.* 1).

ADJUSTMENT OF THE ROTARY MOVEMENT

A large open scale facilitates precise setting of this adjustment. The rotation is locked by a crown which requires only a quarter-turn to fix or release the movement. The special design of this lock ensures ease and simplicity of adjustment of the rotatory movement.

ADJUSTMENT OF THE EARPOSTS

The earposts are of perspex and while they show on the X-ray film, do not obscure detail in the region of the basisphenoid bone. Adjustment is carried out by a coarse-pitch screw. By this means the earposts may, if necessary, be moved quickly, that is to say, two turns of the adjustment separates the earplugs by $\frac{1}{2}$ in., but at the same time the adjustment is very fine and sensitive, because a quarter-turn will separate or approximate the earposts by $\frac{1}{16}$ in., or one-eighth turn makes an adjustment of $\frac{1}{32}$ in.

THE WEDGE FILTER

A duralumin wedge filter is provided to bring out detail in the region of the nasal bones and the soft-tissue outlines of the profile. These structures are usually too heavily exposed to be visible in the X-ray film if some of the X-radiation is not held back by such means as a graduated metal filter.

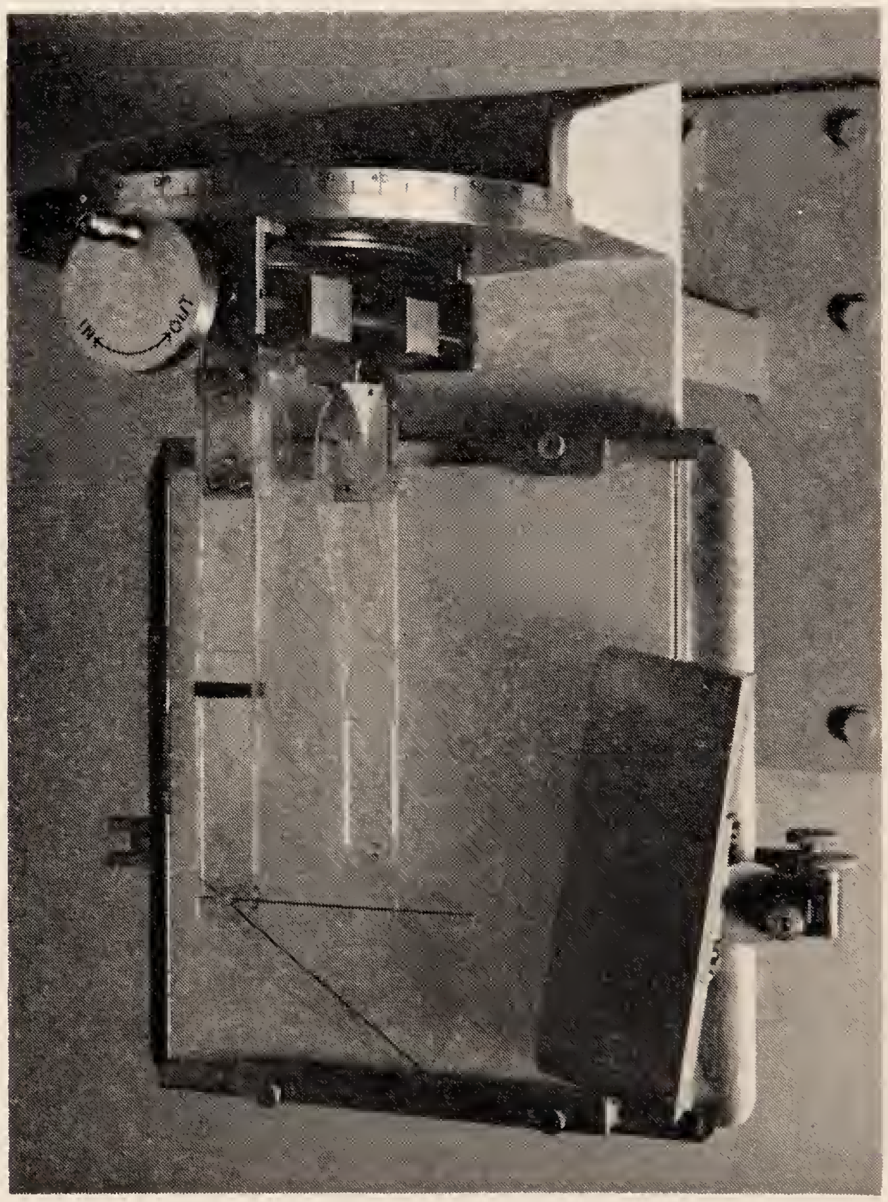

Fig. 1.—The Adams cephalostat with wedge filter, protractor, and X-ray cassette in position. A rigid wall-mounting bracket can be provided.

THE PROTRACTOR

The protractor is used to aline the Frankfurt plane horizontally or to any desired angulation to the horizontal (Adams, 1963). A small spot of

* Obtainable from N. Taylor (Engineering) Ltd., Broom Road, Parkstone, Dorset.

A Demonstration presented at the Country Meeting held in Eastbourne on 20 May, 1966.

lead foil or black paper is placed over the orbital point with a light smear of petroleum jelly. The patient is then asked to raise or lower the head until the spot is alined with the horizontal or at any other required alinement. A lead-foil spot will show on the X-ray film and may be used as a check in the assessment of the position of the orbital point.

GRIDS, CASSETTES, AND INTENSIFYING SCREENS

These are standard X-ray equipment and the specification of these items will depend on the X-ray technique employed.

The cephalostat is designed to use 10 in. × 12 in. films, and the cassette holder will accept standard cassettes of this size.

The modern all-metal type of grid, which is so fine that the grid lines are hardly visible in the film, is recommended. Such grids do not require to be moved during the exposure and may simply be fixed in front of the film cassette and left in position. Personal preference will dictate which type of grid will be required, but an all-metal type with 100 lines per inch, ratio 12 : 1 focused at 140 cm. is strongly recommended.

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SOME CASES SHOWING THE DELIBERATE LABIAL MOVEMENT OF THE UPPER INCISOR APICES DURING THE REDUCTION OF THE OVERJET, WITH SPECIAL REFERENCE TO THE LIP BEHAVIOUR

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One of the accepted maxims in clinical orthodontic teaching is to avoid retroclining the upper incisors when retracting them. There are many good reasons for this, both aesthetic and functional, apart from the physical limitation imposed by the labial periosteum and the possibility of incisal apical resorption.

However, 3 cases are presented where the normal clinical approach was deliberately reversed. In each case, the upper incisor apices were encouraged to move labially during the reduction of the overjet. This was done in order to position the upper incisor tip precisely, relative to the lower lip function.

The lip behaviour was illustrated by a short film during the meeting at which the paper was read. This film is used as the basis for a discussion on the relative importance of the various portions of the total activity of the lip.

Case 1

This boy, aged 9 years, attended for treatment in the late mixed dentition stage. The tracing (*Fig.* 1) shows one central incisor proclined and impinging into the lower lip and the other central incisor retroclined and controlled by the lower lip. The general features of the lip and skeletal morphology can be seen (*Fig.* 1). He had rather full competent lips. The skeletal base was Class I or possibly a very mild Class II with a slightly low maxillo-mandibular planes angle.

The aim of treatment was to retract the most proclined upper central incisor. A simple upper removable appliance was used with a high labial arch and an individual flapper spring acting only on the proclined incisor.

The proclined upper central incisor was retracted in three and a half months. Lack of space prevented complete retraction to the same labiopalatal position as the retroclined upper central incisor. The tooth was not retained and it relapsed labially when the appliance was discarded.

The proclined upper central incisor was again retracted with a similar appliance, but this time the flapper spring was activated on the incisal tip rather than at the gingival margin. During this re-treatment the overjet was reduced by a slightly greater amount, since the tooth probably rotated about its contact points with the other incisors. The re-treatment took 5 months. The retracted incisor was not retained and remained stable.

Tracings of the position of the retracted incisor at the end of each period of treatment are shown (*Fig.* 2). The difference between the two positions is minimal. This small difference in incisal positioning can again be seen if the models *centre left* are compared with the models *centre right* (*Fig.* 3). The change in position of the upper left central incisor is barely visible in the anterior view. The lateral view makes it easier to see the changes in overjet of the upper left central during the treatments. That the difference is important in terms of stability can be seen in the models *top right*. The further slight reduction in overjet of the upper left central incisor permitted the lower lip to function labial to it. The models *bottom centre* show the case a year after treatment. The upper incisor imbrication increased but it was decided to accept the crowding.

Comment

The improvement in the reduction of the overjet of the upper left central during the re-treatment can be measured on the lateral skull films (*Fig.* 4). Between these two films there is a difference in the position of the retracted incisor tip of one millimetre in the overjet and half a millimetre in the overbite. The chief point to be made from this first case is that, during treatment, the positioning of the upper incisor tip relative to the lip behaviour or posture can be very critical. *A millimetre can matter* in certain types of Class II cases. Indeed, this is probably the aetiology of the original incisal relationship.

Presented at the Country Meeting held at Eastbourne on 20 May, 1966.

Growth changes in other structures can never be ignored but the overall treatment was completed in ten and a half months.

Case 2

This boy, aged 9 years, presented with a Class II, division 1 malocclusion, with proclination of all four upper incisors (*Fig*. 5). He also was treated, relapsed, and was then re-treated successfully. His lip morphology was different from the first case in that he had an upper lip of medium thickness with a very thin lower lip which was strap-like during expressive behaviour (Ballard, 1957). At the initial examination he was thought to have had mild lip incompetence. The skeletal morphology was a Class I or a very mild skeletal II base and was somewhat similar to the

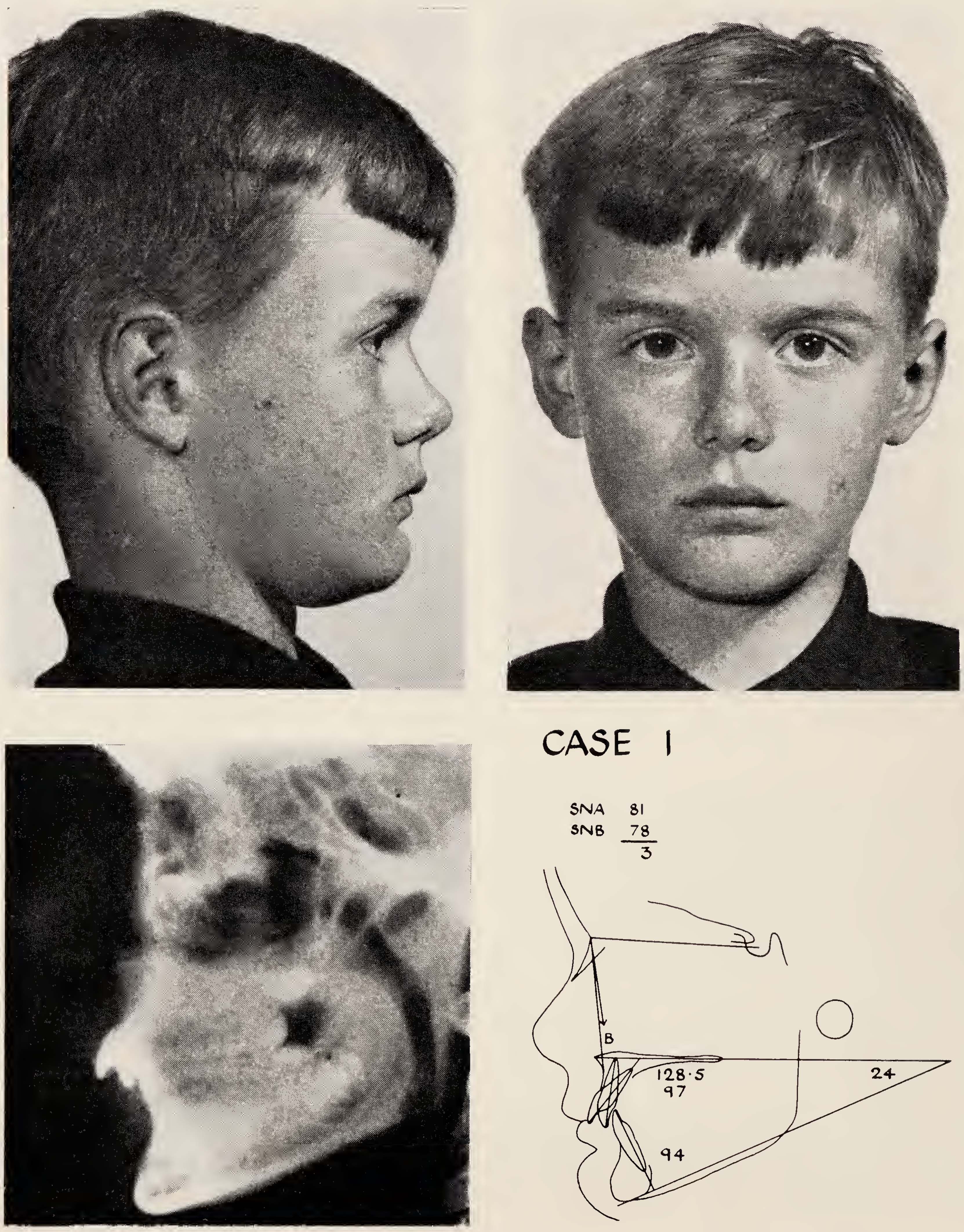


Fig. 1.—*Case* 1. Pre-treatment records.

first case (*Fig.* 5). The maxillo-mandibular planes angle was low.

At the start of treatment, four first premolars were extracted. Initially an upper removable appliance was used, but ultimately treatment was completed with

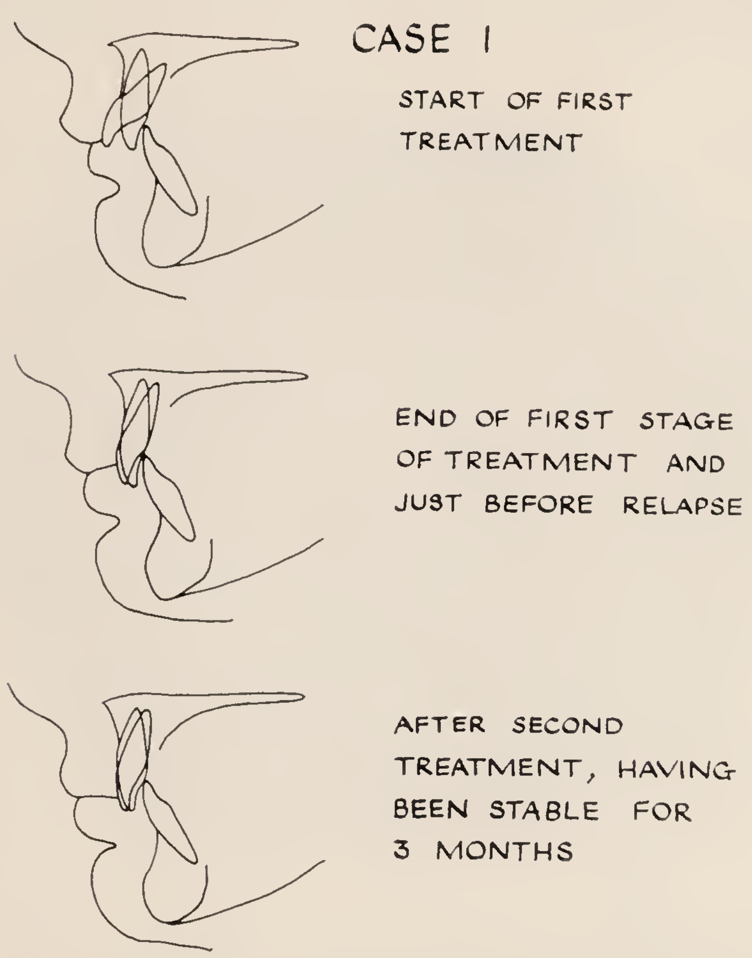


Fig. 2.—*Case* 1. Tracings of the lateral skull films to show the changes in position of the incisal tip and apex of the proclined central incisor.

full upper and lower multiband appliances. The result at the end of the first treatment is shown on the models *centre left* (*Fig.* 6). At this stage, the lower lip appeared to be controlling the upper incisors during the habitual lips-together position. Although the upper incisor bands were left on with a sectional retainer, the upper incisors rapidly relapsed.

It appeared that the lower lip was just catching beneath the upper incisor tips during lip function and this resulted in depression and proclination of the upper incisor crowns.

The case was re-treated with upper removable appliances supported by extra-oral traction. The upper canines were retracted and the overjet again reduced. On this occasion, towards the end of the incisor retraction, the labial bow was lowered towards the incisal tips to encourage the upper incisor apices to move labially. By this means the overjet was completely reduced making it impossible for the lower lip to function below the tip of the upper incisor. The case was retained at the end of re-treatment for three and a half months.

THE INTERINCISAL SPACE

This area is triangular in shape and is bounded on two sides by the labial surface of the lower incisors and the palatal surface of the tips of the upper incisors. The interincisal space is indicated by a superimposed arrow (*Fig.* 7A). This space was eliminated during the re-treatment, thus preventing the lower lip from entering the space during function, and so depressing and proclining the upper incisors.

The incisal relationship (*Fig.* 7B) is one of normal overbite but minimal overjet. If it is accepted that this is the incisal relationship most likely to be stable with this type of lip morphology and behaviour, then whether the upper incisor apices are moved labially or palatally to achieve this incisal relationship is dictated by the skeletal base and limited only by the amount of labial and palatal bone. If the skeletal base is a mild Class III or Class I, the upper incisor apices can be moved labially to produce this incisal relationship. If the skeletal base is a moderate or a severe skeletal II, then some palatal movement of the upper incisor apices may be necessary to produce the same incisal relationship. The important point is to reduce the overjet completely in order to eliminate this interincisal space.

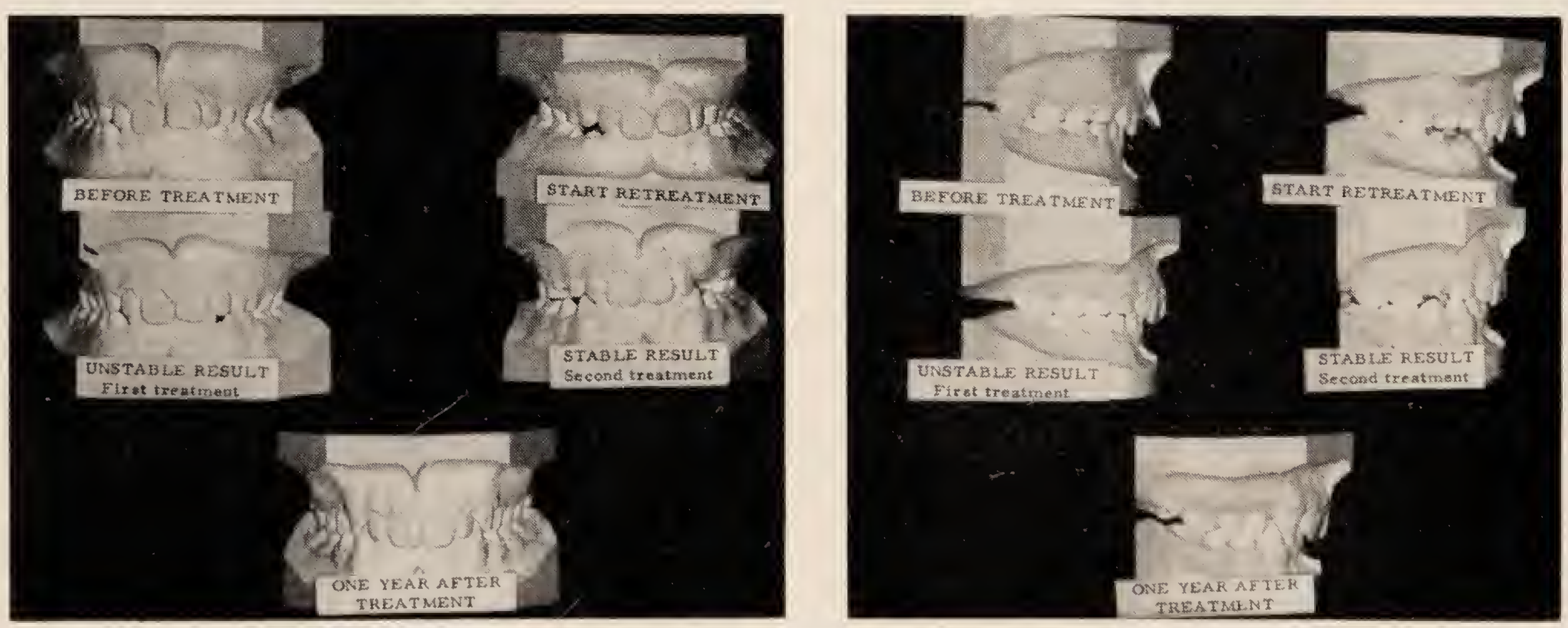


Fig. 3.—*Case* 1. Anterior and lateral views of the models.

In seeking this incisal relationship, excessive retroclination of the upper incisors should be avoided. This is not only aesthetically unsatisfactory and potentially dangerous to the apices, but also the lower incisor tips would fail to occlude with the upper incisor cingula and maintain a normal overbite.

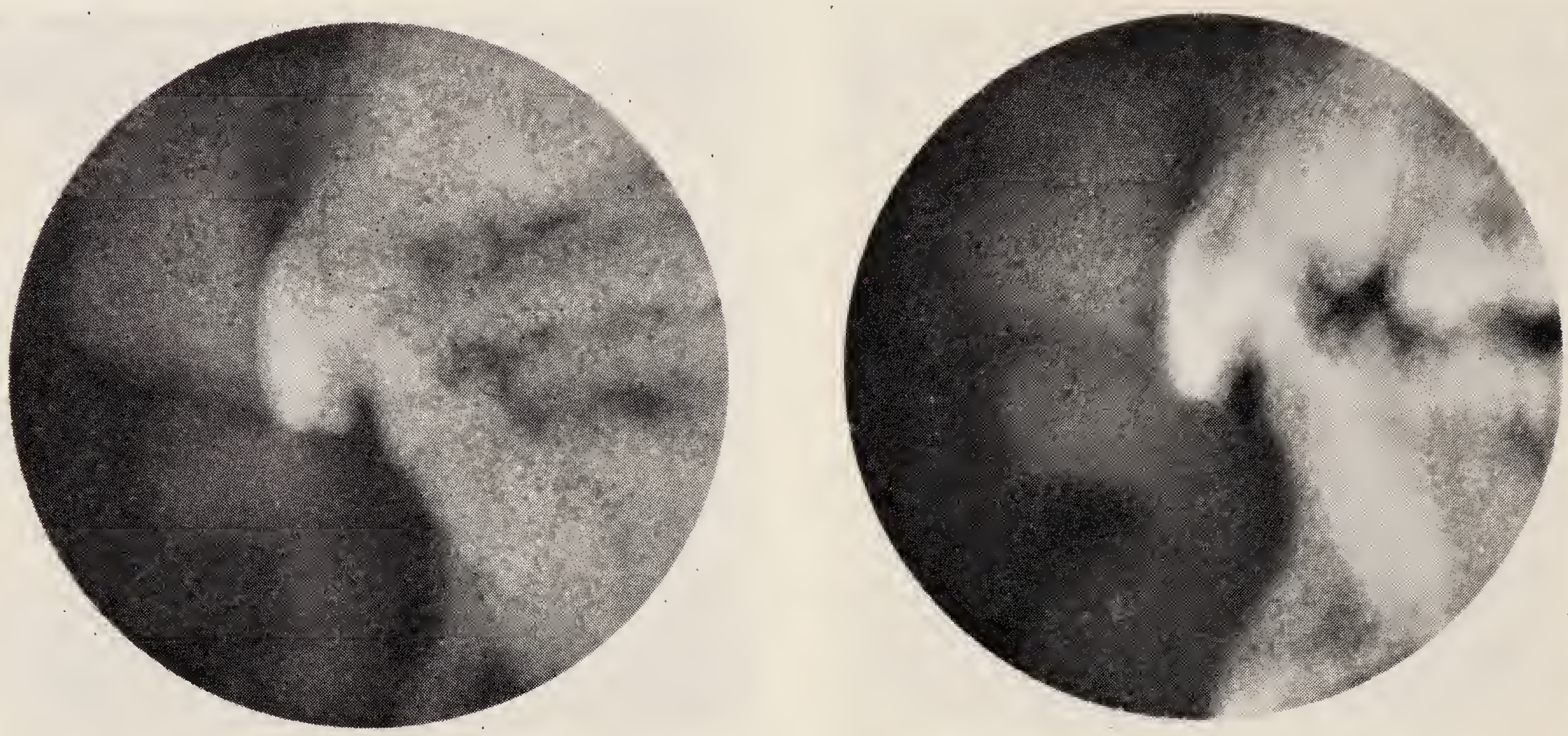
The Inner Surface of the Lower Lip

In order to study lip movement, post-treatment cine X-rays films were taken for each patient. Frame by frame tracings were made of the lips, from a lips-apart to a lips-together position. These showed that the portion of the lower lip contacting the upper incisor during lip movement is quite well down on the inner mucosal surface of the lip. The probable position of this zone is indicated between the two arrows (*Fig.* 10B). The width of this zone of functional contact can vary. It was narrowest in this patient and widest in *Case* 2. The height of this area of functional contact can also vary. It was highest in this case and furthest towards the vestibular reflection in *Case* 2.

The vertical movement of this zone of functional contact was affected by the path of closure of the mandible. It also seemed that the movement of this mucosal area was facilitated by the labial surface of the upper incisor facing anteriorly, with the incisal one-third of the labial surface facing very slightly antero-inferiorly.

The lip line is formed by the most superior border of the lower lip. It marks the upper limit of that portion of the lower lip which is assumed to contact the upper incisors during the habitual resting position of the lips.

If it is accepted that lip behaviour is important in the control of the upper incisors, in addition to the habitual resting posture, then the important zone of the lip during behaviour is not limited by the lip line but is an area on the inner surface of the lip (Lightoller, 1926).



A   B

Fig. 4.—*Case* 1. Incisal region of the lateral skull. A, End of first unsuccessful treatment; B, Stable result, three months after re-treatment. In the unstable position, the retracted incisor has a greater degree of overjet than the more retroclined incisor which had always been controlled by the lower lip. At the end of re-treatment the proclined incisor has been retracted a little further and is stable.

Case 3

This girl, aged 14 years, presented with a Class II, division 1 malocclusion. Her lips were of medium thickness and were slightly more incompetent than the previous cases. She was also described as having strap-like retraction of the lower lip during expressive behaviour (*Fig.* 8). The general features of the skeletal morphology were a mild skeletal III base with a moderately low maxillo-mandibular planes angle (*Fig.* 8). This patient is most typical of the small group of Class II, division 1 cases which can be treated with an appliance designed to move the upper incisor apices labially. It is not possible to retract the upper incisors and eliminate this triangular interincisal space without the upper incisor apices moving upwards and forwards. Since this was appreciated before starting treatment with this case, re-treatment was not necessary.

Treatment was started with a short period of extra-oral traction, designed to move the upper buccal segments into a good Class I relationship. A free-sliding Watkin pin and tube arch (Clifford, 1965) was then used to close the median diastema, aline the central incisors, and reduce the overjet completely (*Fig.* 9). The case was retained for 1 month. The incisor rotated about a point roughly half way between the apex and the alveolar crest. This appliance is excellent for treating a Class II, division 1 incisal relationship on a mild skeletal III base, with a shallow anterior intermaxillary height. The median diastema was closed at the end of treatment but partially reopened after retention was discontinued.

The film shown was taken after all retention had been discontinued. Each patient was instructed to say the following sentence: ' I could see by his shoes that he was a very poor man. ' This was followed by a pause, a swallow, and, finally, a smile. This sequence was repeated a number of times and filmed at normal and high speed—16 and 64 f.p.s. Cineradiographs were taken at 64 f.p.s.

DISCUSSION

The first two cases illustrated relapsed after treatment but were subsequently re-treated successfully. From a study of the small changes

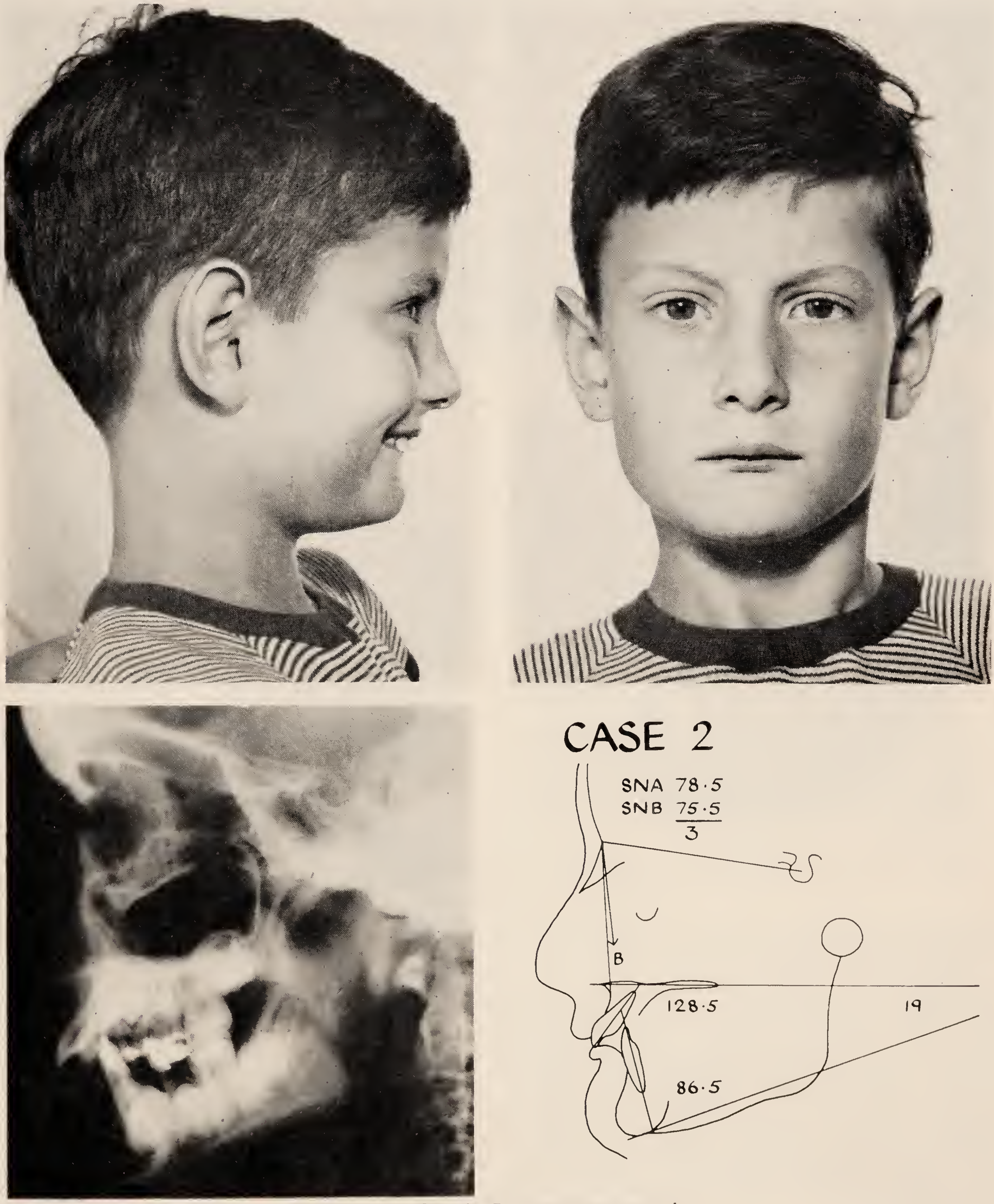


Fig. 5.—*Case* 2. Pre-treatment records.

that occurred in incisal overjet, overbite, and axial inclination from the relapsed to the successful results, it could be inferred that in certain types of Class II cases these small changes in

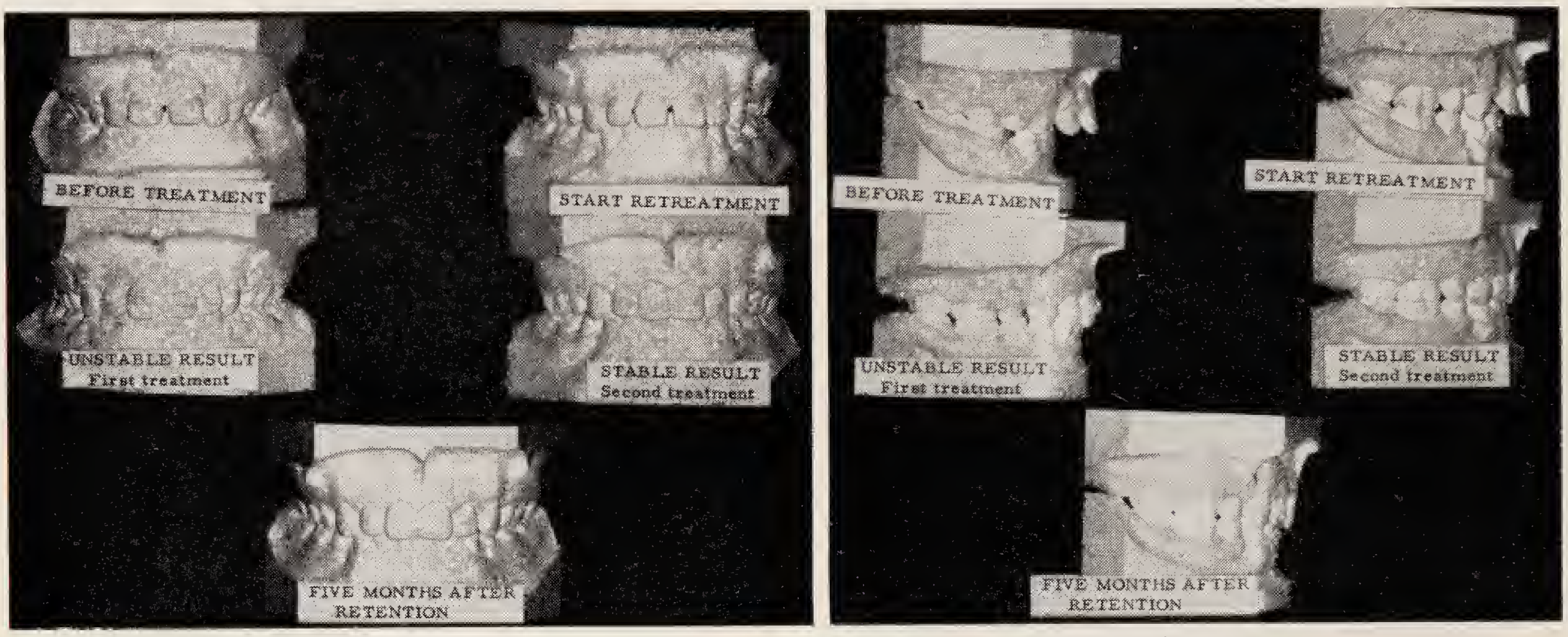


Fig. 6.—*Case* 2. Anterior and lateral views of the models.

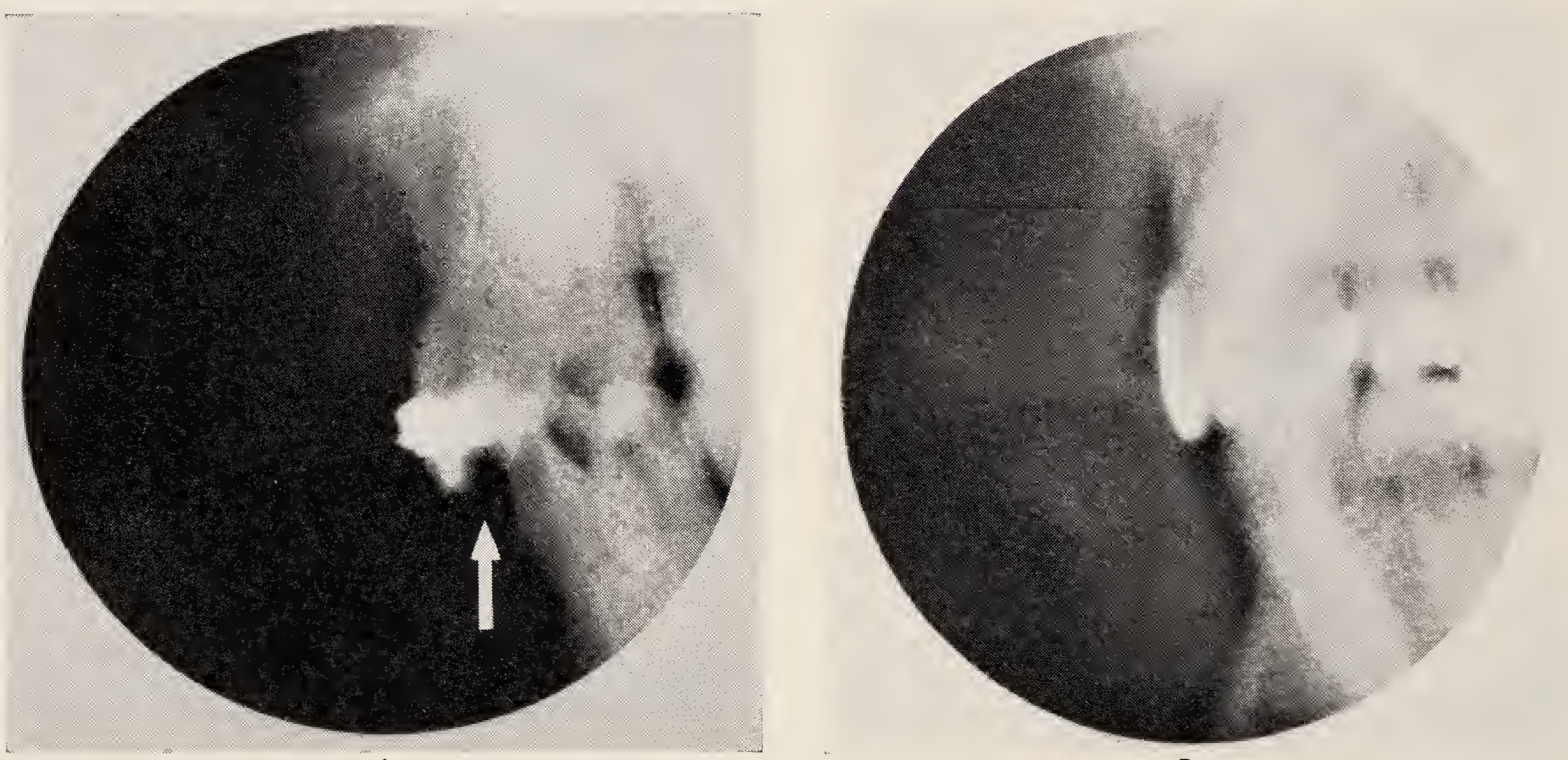

A B

Fig. 7.—*Case* 2. Incisal region of the lateral skull. A, End of the first unsuccessful treatment; B, Five months out of retention following re-treatment.

incisal positioning are critical to the successful reduction of the overjet.

The important portion of the lower lip during behaviour is not limited by the lip line. The important functional portion of the lower lip is a part of its inner surface. The movement of this mucosal area of the lower lip relative to the tips and labial surface of the upper incisors determines the stability of the upper incisors during movement from a lips-apart to a lips-together position. The width of this area and its height relative to the lip line can vary (*Fig*. 11).

Total lip activity may be considered under four headings, viz., speech, expressive behaviour (i.e., smiling and laughing), swallowing (including mastication), and the habitual resting posture of the lips. Probably only the last two, swallowing and the habitual resting posture of lips, are important in the control of the upper incisors by the lower lip.

Speech

During speech there is relatively little contact of the upper incisors by the lower lip and such contact as occurs is fleeting.

Expressive Behaviour

Pre-treatment photographs of the second and third cases showed strap-like retraction of the

lower lip during smiling. The film taken after successful reduction of the overjet showed that the lower lip was still firmly retracted below the tips of the upper incisors during expressive behaviour. From this it may be argued that in these two cases strap-like retraction of the lower lip during expressive behaviour was not an important feature when assessing the prognosis.

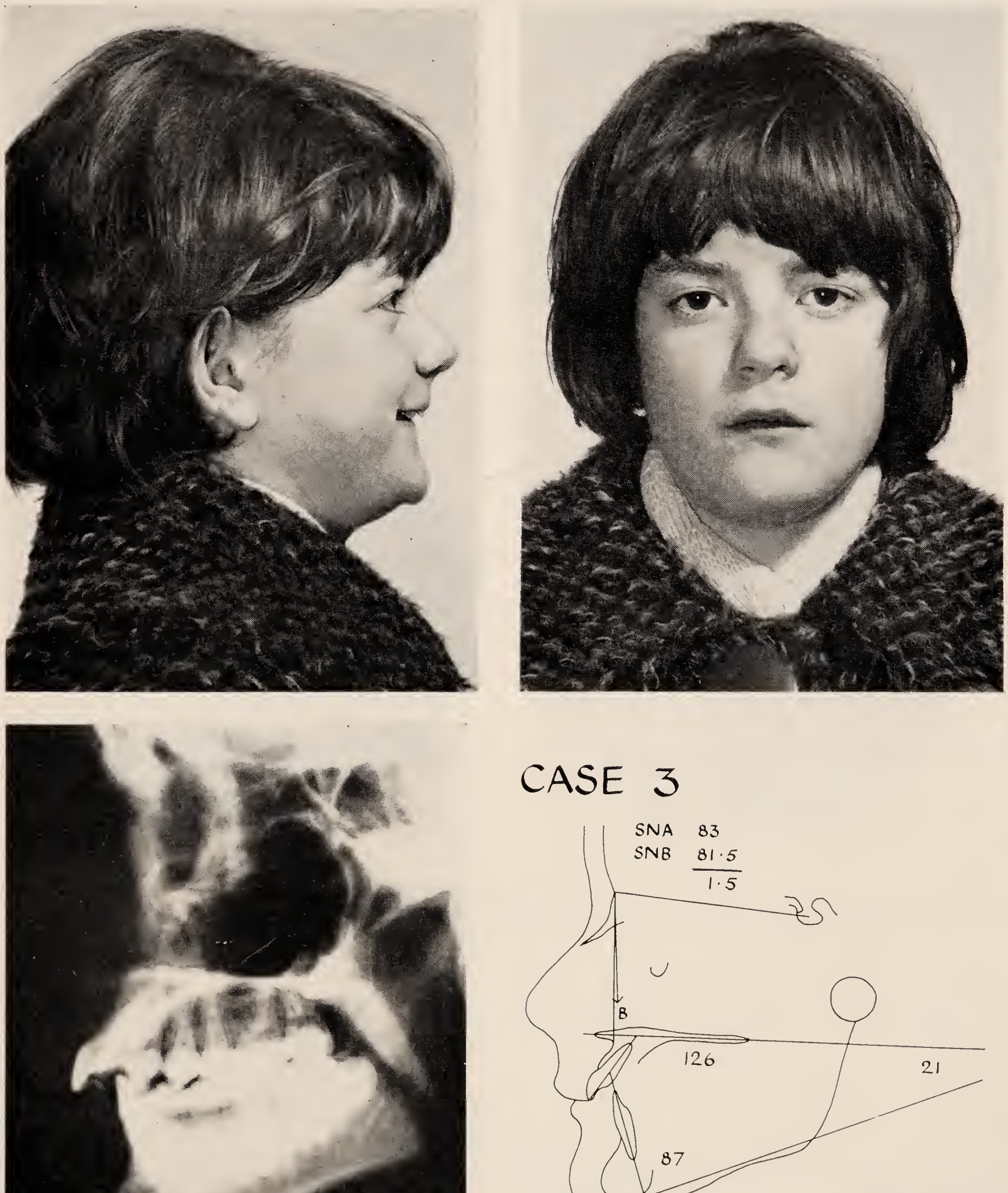


Fig. 8.—*Case* 3. Pre-treatment records.

Swallowing and Mastication

It is during swallowing that the inner surface of the lower lip can be seen flowing over the tip and the labial surface of the upper incisor. The path of movement of this mucosal surface will depend on the path of closure of the mandible. The duration of the lower lip contact with the upper incisor is far longer during swallowing than in speech.

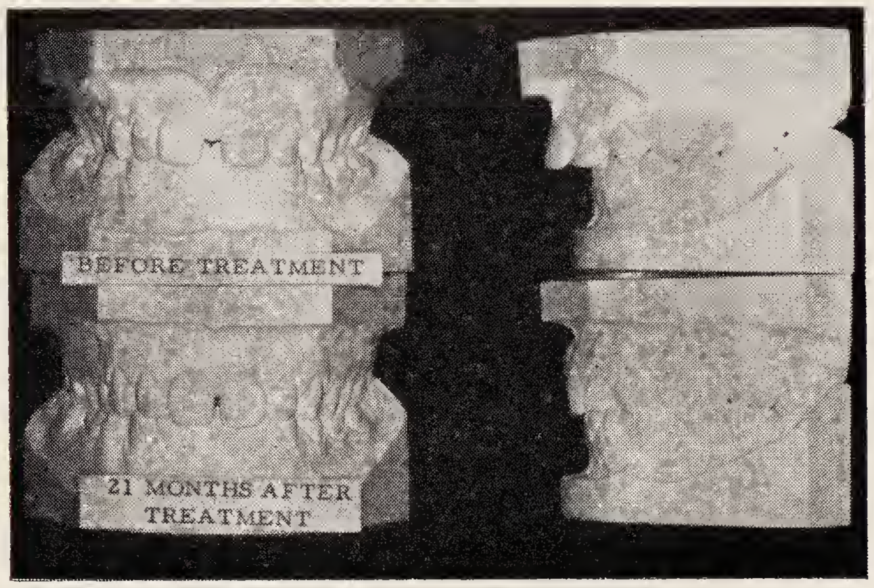


Fig. 9.—*Case* 3. Anterior and lateral view of the models.

Habitual Resting Posture

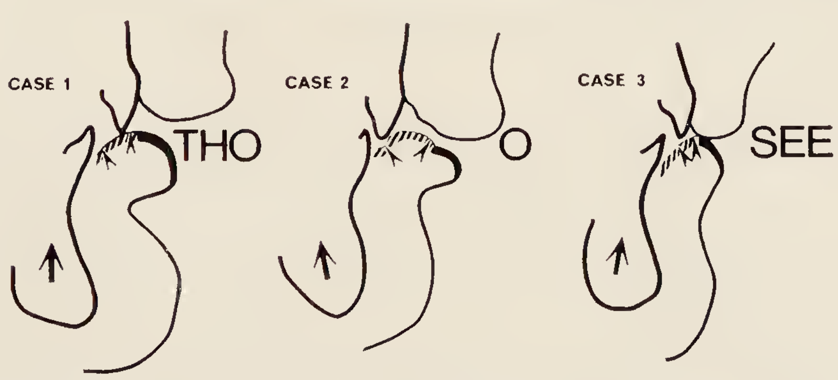
According to Walther (1960), only 18 per cent of a population sample had competent lips. A much larger group, however, have lips which are only slightly incompetent. This group keep their lips together to maintain a state of functional competence. As the morphological inadequacy of the lips becomes progressively greater, so the effort needed to keep the lips together increases. This results in a shortening of the length of time during which functional competence is maintained. Conversely the lip pressures exerted during these shorter periods of functional competence increases due to the effort needed.

Presumably there is a summation of the pressures produced on the labial of the upper incisors during the total activity of the lips. Whereas it is possible to assess the contribution made during swallowing, it is more difficult to assess the proportion contributed to the total lip activity by the habitual resting posture of the lips. This is principally due to the infinite range of morphological variation from lip competence to gross lip incompetence (Hopkin and McEwen, 1957). It is possible that the relative importance of behaviour and posture varies from case to case.

It is realized that in speaking of incisor position one cannot disassociate the effect of the lips from that of the tongue, the skeletal pattern, the anterior intermaxillary height, the incisal,

A B

Fig. 10.—*Case* 3. Incisal region of the lateral skull. A, Before treatment, and showing the small lobule of the lower lip which has entered the interincisal space. B, Eighteen months out of retention.



Portion of the mucosal surface, contacting the upper incisors during lower lip function.

Fig. 11.—Tracings of selected frames from cineradiograph. The teeth are coming into occlusion following the enunciation of separate syllables.

occlusal plane, or of the amount of dental arch support.

Deliberate labial movement of upper incisor apices cannot be used as a method of treatment where the skeletal base is more than mildly Class II since the upper incisor apices would come into contact with the labial periosteum before the overjet was reduced. There would also be a marked increase in overbite.

SUMMARY

The aim of treatment in the 3 cases demonstrated has been to produce an incisal relationship of normal overbite but minimal overjet; in short, to eliminate the interincisal space. The inner surface of the lower lip was consequently unable to enter this space to depress and procline the upper incisors. The elimination of the interincisal space was achieved by retracting the incisors with deliberate labial movement of their apices. This also caused the labial surface of the upper incisor to face anteriorly, with the incisal one-third facing slightly antero-inferiorly. The mucosal surface of the lower lip seemed able to slide over this incline more easily and it facilitated the achievement of functional competence. The position of this mucosal area of contact during lip behaviour is on the inner surface of the lower lip and always inferior to the lip line.

The treatment plan could be summarized by saying that the incisal tip has to be so positioned that the lip cannot get underneath it.

Acknowledgements

I would like to thank Professor C. F. Ballard, Mr. S. G. McCallin, and Dr. J. R. E. Mills for permission to use their cases, and also Mr. P. Vig for his help with the cineradiography. The cine-camera was purchased with a grant supplied by the Central Research Fund of the University of London.

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DISCUSSION

Dr. J. R. E. Mills asked if Mr. Orton thought this type of treatment was indicated in many Class II, division 1 cases or in only a few—perhaps those on a Class I or mild Class III base.

Mr. Orton said that he felt this strap-like activity of the lower lip in expressive behaviour was of little importance. He himself would suggest that the effect of this contraction of the lower lip on the lower incisors was to hold them back. This might position them so far back that it was difficult to get the upper incisors far enough back to meet them. He wondered if Mr. Orton would agree with this.

Mr. Orton said that it was possible to find the type of lip behaviour which had been demonstrated associated with all variants of the skeletal base from Class III to severe II. With this type of lip behaviour there must be complete reduction of the overjet. The direction of movement of the incisor apices to achieve this could vary from labially on a mild III base to palatally on a severe skeletal II base. Partial reduction of the overjet was pointless in this type of case.

Two of the three cases did present with some retroclination of the lower incisors. This would affect the prognosis if it were associated with a severe skeletal postnormality.

Mr. M. S. E. Gould agreed with Mr. Orton about the importance of swallowing and of expressive behaviour and their effects upon incisal position, but he also thought that the resting position was important. People swallowed in different ways, very often depending on the substance being swallowed. Further, what they were doing before they swallowed often affected the manner in which they swallowed. In the dental chair swallowing was often not of the type normally produced. In Class II, division 2 cases, there was a tooth-apart swallow, probably due to the fact that there was not enough room in a Class II, division 2 mouth for the tongue and the substance being swallowed, so they just had to lower the mandible to increase the intra-oral space. When they did this there was a gap between the maxillary and mandibular teeth and in order to swallow, the tongue had to go out laterally between them, so that the action in this type of swallow was very different from the teeth-together Class I type of swallow. In Class II, division 1 cases the subject had to do something quite different in order to make the seal.

It was very interesting that Mr. Marx, in his electromyographic study, had found that in bimaxillary proclination cases, contrary to expectation, there was increased activity of lips and, conversely, a decreased activity of the muscles in bimaxillary retroclinations. Picton and he had found the same sort of thing with pressures acting on the teeth; there were greater pressures on the incisors from the lower lip in the Class II, division 1 than in Class II, division 2 cases. They had also found that there was no difference between the pressure on the incisors of retroclined Class II, division 2 cases and normal cases. Very often, in Class II, division 1 cases, the force was opposed and cancelled by the tongue.

With regard to expressive behaviour, there was a difference. The lower lip acted in isolation against the lower incisors, the mandible was dropped and the tongue rolled back and hence the action of the lower lip had a very positive unopposed effect. In the habitual resting position there was often a negative pressure within the mouth. The teeth were not together. The lower lip was often drawn in against the incisors and he thought that it was in these cases that the relationship established by the inner surface of the lower lip to the labial surface of the incisor was very important.

He asked if Mr. Orton, having commented on the thickness of lips in the subject, had noted any correlation between this thickness and the type of activity or incisal relationship in his cases.

Mr. Orton said that in the paper, he had laid a great deal of emphasis on the lips. He had done so, not because he thought that the lips could be looked at in isolation from the other morphological features, but because the lip behaviour seemed to be the distinguishing feature of these three cases.

As Mr. Gould said, within each individual the pattern of swallowing might vary according to what was being swallowed. Also, the pattern of swallowing may differ depending on the morphology of the individual. If Mr. Gould and Dr. Picton, or their co-workers in the field, were able to make continuous measurements and relate them to which phase of soft-tissue activity was taking place, it might then become possible to state with precision which portion of the total activity of the lips is responsible for the incisor position in the individual studied. If this type of study could then be extended to cover a reasonable range of morphological variants, particularly lip morphology, we would have some of the objective clinical yardsticks we lack at present.

The width of the red margin of the lip was used to give an indication of lip morphology in the three cases. He appreciated that this was not too closely related to the total thickness of the lip which he had not measured.

Mr. F. Allan said that he had had a number of similar cases where lips were potentially competent or were competent after treatment, with skeletal patterns varying from mild Class II to skeletal I's. Yet a successful result in the same way as Mr. Orton's was not stable, not because in resting posture or expression the lower lip could get behind the upper incisors, but because the patients were so used to having the upper incisors in a particular position that the lower lip was used to force the upper incisors back where they were in the first place. In several cases where he had noticed that, he had brought it to the patient's attention and was able to get a stable end-result as they were subsequently restraining themselves.

Mr. Orton replied that when a tooth was moved from one position of minimum energy to another position of minimum energy, the soft tissues appeared to adapt almost instantaneously to the new position. If the lower lip did not adapt to the new position of the upper incisor tip then presumably the incisor was in an unstable position. The treated position of the incisors might be just unstable in the type of case Mr. Allan had described. If this discrepancy was minimal it might be possible to consciously compensate for the small discrepancy but this would seem unlikely.

Mr. W. Nichol asked Mr. Orton if he thought that looking at the teeth in occlusion was the right way to do it. Did he think, perhaps, that if he looked at them in the resting position of the mandible he might have a different sort of shape.

Mr. Orton agreed with Mr. Nicol that any consideration of the lips with the teeth in occlusion would be a very limited one. But the same was also partly true of the lips with the mandible at rest. Since behaviour and posture were such rapidly interchanging parts of a moving system, the study must be a dynamic one. For this type of study cineradiography was most useful. One could get 10 seconds of film for an exposure of 1 roentgen. This was roughly the equivalent of two lateral skull films. But since one was limited to 10 seconds of film the patients had to go through a set drill and this could be limiting.

A SURVEY OF CONGENITALLY MISSING TEETH, EXCLUDING THIRD MOLARS, IN 6000 ORTHODONTIC PATIENTS

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There have been several previous surveys to establish the prevalence of congenitally missing teeth. In 1937, Dolder examined 10,000 Swiss schoolchildren aged from 6 to 15 years and found that 3·4 per cent had missing teeth. Werther and Rothenberg (1939) surveyed a thousand children who attended a dental school clinic at the University of Pennsylvania, and 2·3 per cent of those examined were found to have a partial anodontia. In 1943, Byrd did a survey of the incidence of supernumerary and congenitally missing teeth in 2835 children aged 4–14 years. The figure for missing teeth was 2·9 per cent. Brekhus, Oliver, and Montelius (1944) carried out a study of the pattern and combination of congenitally missing teeth, including third molars, in man. They investigated 11,487 patients at the Dental Clinic at the University of Minnesota and found 1·5 per cent with missing teeth. Brown (1957) surveyed 5276 patients from the Department of Paedodontics, State University of Iowa, and found 4·3 per cent of children had one or more missing teeth. Grahnen (1958) examined 1006 Swedish schoolchildren and found 6·1 per cent with partial anodontia. Glenn undertook surveys in 1961 and 1964 using children from two private paedodontic practices. His first survey included 777 patients, of whom 5·2 per cent had missing teeth, and the second found that out of 925 patients 5·1 per cent did not have a full complement of teeth. In 1962, Sabes and Bartholdi surveyed partial anodontia of the permanent dentition in 40,204 patients, using mostly adults in their sample. Their information was obtained from Hospital records, and showed that 0·39 per cent of this sample had missing teeth. Sanchez, in 1964, examined 900 Argentine schoolchildren aged from 6 to 15 years. His survey of partial anodontia, which included third molars, showed a prevalence of 14·2 per cent. The result of these surveys will be compared with the current work later in the paper.

MATERIAL

The material for the present survey consisted of 6000 consecutive patients who were referred to an orthodontic practice and who required treatment: 3597 (59·95 per cent) were female and 2403 (40·05 per cent) were male (*Fig.* 1). All but a very few were in the age range of 7–14 years.

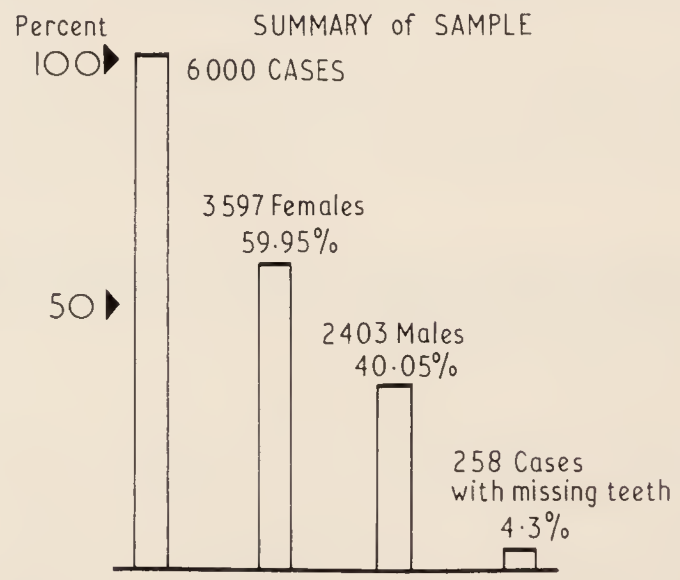

Fig. 1.—Summary of sample.

Each patient was charted and radiographed for the presence of unerupted teeth, using intra-oral periapical films. If the examination showed a missing tooth, a careful history was taken to elicit information concerning previous extractions. When there was any reasonable doubt that the tooth was not congenitally missing, and might have been previously extracted, the case was excluded from the sample. It is, of course, possible that a tooth germ might have been removed when a deciduous molar was extracted. Although such accidents do occur, they are rare. If anything, the figures which will be given are on the low side, because of the relatively strict terms in which the cases were assessed.

The parents of the children were questioned as to whether there was any history of missing teeth within the family. This information cannot

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be exact, as many families would not know a complete history in relation to congenitally missing teeth, nor might they be aware if they themselves had had congenital absence of, say, second premolars.

None of the patients with partial anodontia exhibited any obvious sign of other ectodermal deficiencies.

RESULTS

The results showed that 258 (4·3 per cent) of the patients had one or more teeth congenitally

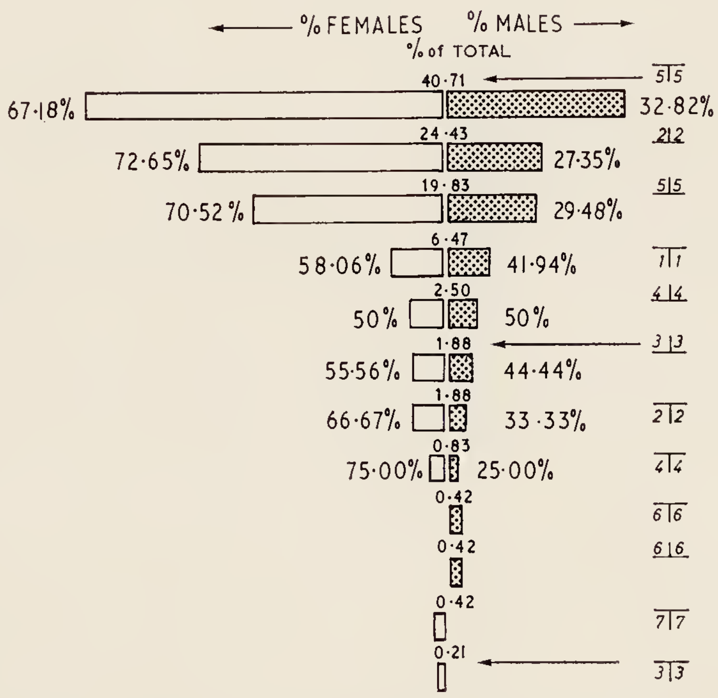

Fig. 2.—Percentage of individual types of teeth missing related to the total number of missing teeth in the sample.

missing. This total was made up of 176 (68·22 per cent) girls and 82 (31·78 per cent) boys (*Table I, Fig.* 1). When these figures were subjected to a 'chi squared' test, the result showed that this greater frequency of congenitally missing teeth in the girls, when compared with the boys, was highly significant ($P<0{\cdot}01$).

ORDER OF MISSING TEETH

The order of teeth most frequently missing was found to be:—

1. The lower second premolar (40·71 per cent)
2. The upper lateral incisor (24·43 per cent)
3. The upper second premolar (19·83 per cent)
4. The lower central incisor (6·47 per cent)

Together these four groups made up over 90 per cent of the total missing teeth. The upper canines (1·88 per cent of the missing teeth) were

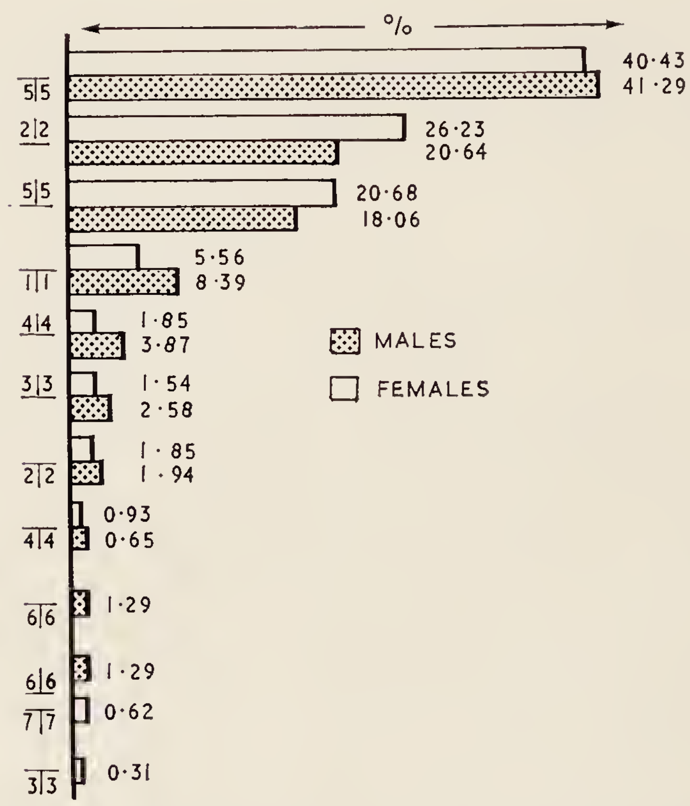

Fig. 3.—Male/female distribution of missing teeth. The horizontal columns represent the number of each type of tooth missing expressed as a percentage of the total number of missing teeth in the sex indicated.

sixth in order of ranking and this was thought to be relatively high (*Fig.* 2). There was no difference in the order of congenitally missing teeth between the males and the females, although there was some difference in the proportions of

Table I.—Analysis of Sample

	No. of Cases	Female	Male
Without missing teeth	5742 (95·7 per cent)	3421 (59·58 per cent)	2321 (40·42 per cent)
With missing teeth	258 (4·3 per cent)	176 (68·22 per cent)	82 (31·78 per cent)
	No. of Missing Teeth	Female	Male
	479	324 (67·64 per cent)	155 (32·36 per cent)

The total number of individual missing teeth was 479, consisting of 324 (67·64 per cent) teeth from females and 155 (32·36 per cent) from males.

the total, when the number of missing teeth in each sex was expressed as a percentage of the number of children with missing teeth in that sex (*Fig.* 3).

When the number of individuals with congenitally missing teeth was expressed as a percentage of the total number examined, the order was the same, except for the lower second molars, which then preceded the first molars. However, the numbers of teeth in this area were small and the differences in the order were not significant (*Table II*).

Of those children with missing teeth, over half (55·81 per cent) had only a single missing tooth; 29·45 per cent had two teeth missing. These two groups together made up over 85 per cent of the sample. The individuals with 6, 7, 8, and 9 teeth missing were represented by females only (*Fig.* 4). The order of ranking between males and females was very similar, the only differences being where the greatest number of teeth were congenitally missing. In this area of the sample the number of cases is so few as to give the figures little significance (*Fig.* 5). However, there was an appreciably higher proportion of females with only two teeth missing compared with the males, and the reverse was true of those cases with only three teeth missing.

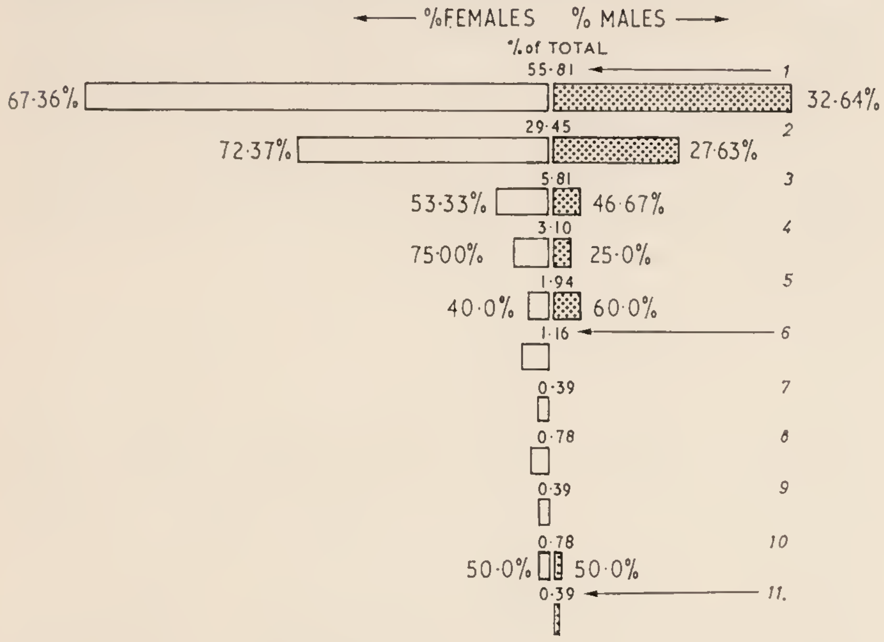

Fig. 4.—The total of the number of missing teeth per case (the figures on the right of the drawing) expressed as a percentage of the total number of children with missing teeth.

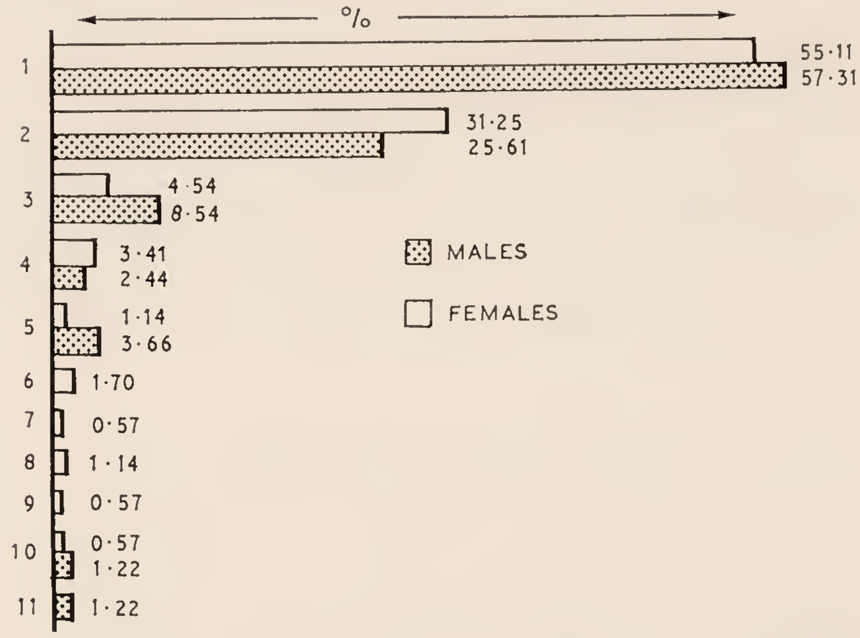

Fig. 5.—Male/female distribution of number of teeth missing per case. The horizontal columns represent the total of the number of missing teeth per case (the figures on the left of the drawing) expressed as a percentage of the total number of children with missing teeth in the sex indicated.

Table II.—Number of Cases with Individual Types of Teeth Missing expressed as a Percentage of the Number of Cases examined

	No. of Cases	Percentage of 6000 Cases
$\overline{5\|5}$	137	2·28
$\underline{2\|2}$	79	1·32
$\underline{5\|5}$	70	1·17
$\overline{1\|1}$	21	0·35
$\underline{4\|4}$	8	0·13
$\underline{3\|3}$	6	0·10
$\overline{2\|2}$	6	0·10
$\overline{4\|4}$	3	0·05
$\overline{7\|7}$	2	0·03
$\overline{6\|6}$	1	0·02
$\underline{6\|6}$	1	0·02
$\overline{3\|3}$	1	0·02

Table III.—Comparison of Distribution of Missing Teeth between Right and Left Side of Both Arches

	Female R	Female L	Male R	Male L
$\overline{5\|5}$	65	66	31	33
$\underline{2\|2}$	43	42	17	15
$\underline{5\|5}$	36	31	16	12
$\overline{1\|1}$	8	10	6	7
$\underline{4\|4}$	3	3	4	2
$\underline{3\|3}$	3	2	2	2
$\overline{2\|2}$	4	2	2	1
$\overline{4\|4}$	1	2	1	—
$\overline{6\|6}$	—	—	1	1
$\underline{6\|6}$	—	—	1	1
$\overline{7\|7}$	2	—	—	—
$\overline{3\|3}$	—	1	—	—
Total	165	159	81	74

LEFT AND RIGHT DISTRIBUTION

There was a remarkable similarity in the total distribution of missing teeth between the right and left hand sides of the arches, the proportions being 165 : 159 for the females and 81 : 74 for

the males (*Table III*). In the maxilla the proportions were 85 : 78 in the females and 40 : 32 in the male; the lower arch figures were 80 : 81 female and 41 : 42 male.

FAMILY HISTORIES

Of the females 9·7 per cent and 10·9 per cent of the males gave a family history of congenitally missing teeth. Together these figures made up 10 per cent of the total number of individuals with partial anodontia (*Table IV*). There were also 2 cases among the females who had a relative with small-sized teeth. However, as indicated earlier, these figures are probably on the low side because of the difficulties of obtaining positive family histories.

Table IV.—Cases giving Evidence of a Family History of Congenitally Missing Teeth

	Number	Percentage
Total	26	10·0
Male	9	10·9
Female	17	9·7

RETAINED DECIDUOUS TEETH

The total number of deciduous teeth that were retained with congenitally missing successors were 205, or 42·8 per cent of the number of missing teeth. Of the missing teeth in males 47·1 per cent had retained primary teeth, and the females had 40·7 per cent of missing teeth with retained predecessors (*Table V*). The second deciduous molar made up 80 per cent of the total of retained deciduous teeth.

SECOND PREMOLARS

As the second premolars were the most common congenitally missing teeth, making up over 60 per cent of the total number, it was thought that it would be interesting to look at this area of the problem a little more closely.

The lower second premolars represented 40·71 per cent of the total number of missing teeth, and in these cases there was a very slightly greater proportion of males as compared with females. The upper second premolars represented 19·83 per cent of the missing teeth, and in these cases the condition was a little more common in the female (*Table VI*). Of the 207 cases which had second premolars missing, 149 (71·9 per cent) had only second premolars absent. Therefore 57·4 per cent of the total number of cases with missing teeth had second premolars only missing. This figure is represented by 63·4 per cent of the male cases and 55·1 per cent of the female ones. Thus the situation was more common among the males than among the females, but there were slightly more teeth missing per case in the females (*Table VII*).

Table V.—Distribution of Cases with Missing Teeth which had Retained Deciduous Teeth

Percentage of missing teeth with retained deciduous teeth	Percentage of males with retained deciduous teeth	Percentage of females with retained deciduous teeth
42·8	47·1	40·7

Table VI.—Distribution of the Total Number of Second Premolars Missing in the Sample

	$\overline{5\|5}$	$\underline{5\|5}$
Total	195 (40·71 per cent)	95 (19·83 per cent)
Female	131 (40·43 per cent)	67 (20·68 per cent)
Male	64 (41·29 per cent)	28 (18·06 per cent)

Table VII.—Cases with only Second Premolars Missing

	No. of cases with missing teeth	Percentage of cases with missing teeth	No. of teeth missing	Percentage of teeth missing
Total	149	57·4	234	48·8
Male	52	63·4	74	47·7
Female	97	55·1	160	49·1

UPPER LATERAL INCISORS

There were 79 cases which had missing upper lateral incisors, and of these 67 (84·8 per cent) had no other teeth missing. Thus 25·9 per cent of the total number of cases with missing teeth

Table VIII.—Cases with only Upper Lateral Incisors Missing

	No. of cases with missing teeth	Percentage of cases with missing teeth	No. of teeth missing	Percentage of teeth missing
Total	67	25·9	97	20·3
Male	15	18·3	23	14·8
Female	52	29·5	74	22·8

had only upper second incisors missing. This figure was represented by 18·3 per cent of the male cases and 29·5 per cent of the female cases (*Table VIII*). Thus it is seen that females with only upper lateral incisors missing far outnumber their male counterparts.

OTHER DENTAL ABNORMALITIES

Although no other ectodermal deficiencies were found among the individuals investigated, a fair proportion of them (17·1 per cent) showed other dental morphological abnormalities. This

Table IX.—Cases with Missing Teeth and other Dental Abnormalities

Total	Male	Female
44 17·1 per cent	13 15·9 per cent	31 17·6 per cent

Table X.—Distribution of other Abnormalities

	Male	Female	Total
Diminutive $\underline{2}$	8*	19*	27
Large other teeth	1	6	7
Smaller other teeth	1*	4*	5
Atypical teeth	2	2	4
Late development	1	—	1
Cleft palate	—	1	1
Hypoplastic teeth	1	—	1
Geminated teeth	—	1	1
	14	33	47

* More than one factor.

figure represents 15·9 per cent of the males and 17·6 per cent of the female cases (*Table IX*). Diminutive upper lateral incisors made up most of these abnormalities. However, some showed that the other teeth present were larger than normal; others that some of the teeth, as well as the upper lateral incisors, were smaller than one would have expected. There were 4 cases of atypical tooth morphology; 1 case of cleft palate, 1 where other teeth were hypoplastic, and 1 where two of the deciduous teeth were geminated. (*Table X*).

ANGLE'S CLASSIFICATION

The distribution of the partial anodontia cases within Angle's Classification is shown in *Fig.* 6.

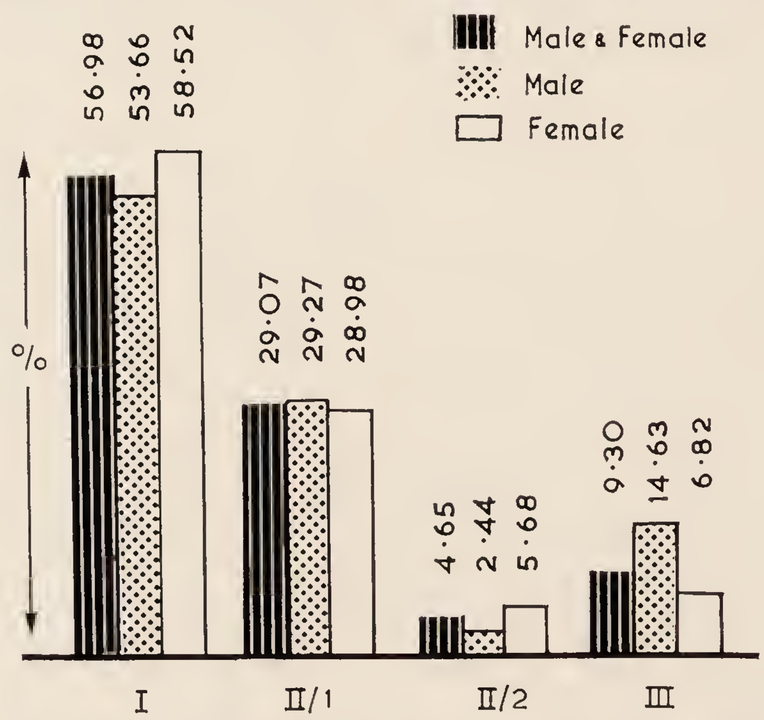

Fig. 6.—Distribution of cases with missing teeth within Angle's Classification.

These figures are more or less what would be expected in an orthodontic practice. The male/female ratio is similar in the Angle Class I and Angle Class II, division 1 groups. In Angle's Class II, division 2 cases there were more than twice as many females as males, and the reverse was true for Class III cases.

A random sample of 500 cases with a complete dentition was taken from the population (6000 cases) studied, and classified according to Angle. The results were then compared with the distribution of the cases with missing teeth (*Fig.* 7). When the figures were subjected to statistical analysis, no association was found between the two groups.

DISCUSSION

In comparison with some previous investigations, the total percentage of missing teeth (4·3 per cent) is a little high, but Glenn's (1961, 1964) figure for a paedodontic practice is even higher, at 5·1 per cent, and Bengström (1930), in a radiographic survey of orthodontic patients,

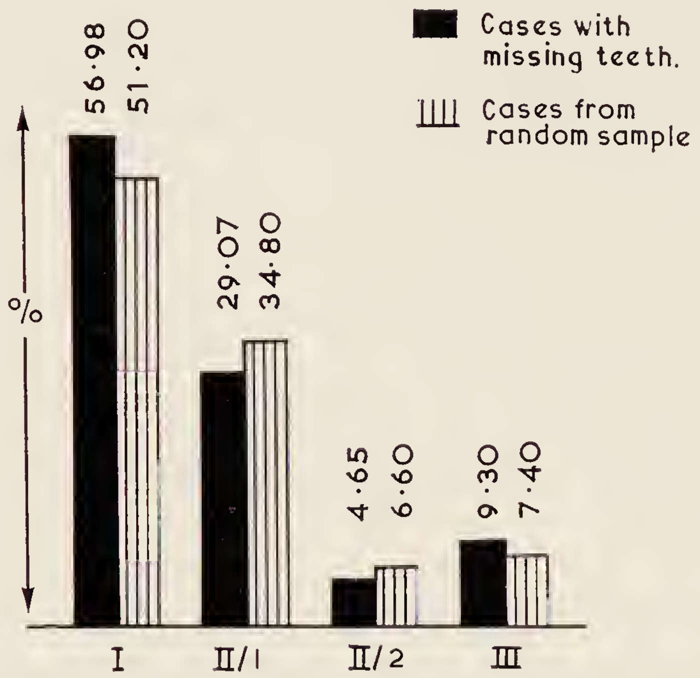

Fig. 7.—Comparison of distribution within Angle's Classification between cases with missing teeth and cases from the random sample.

showed an incidence of 6·5 per cent of missing teeth. Grahnen's (1958) figure is 6·1 per cent. Brown (1957) found a prevalence of 4·3 per cent missing. It is interesting to note that one of the lowest figures given, that of Brekhus and others, (1944) (1·5 per cent), included third molars. One would have thought that this would increase the percentage of missing teeth, as it did with the figures of Sanchez (1964) (14·2 per cent). The latter was the highest figure found. However, Brekhus and others (1944) counted one member only of a family in their figures, when more than one individual in that family had congenitally missing teeth. Sabes and Bartholdi's (1962) figure of 0·39 per cent is very low, and this is probably because their information was obtained from hospital record cards, on which the relevant information may not necessarily have been noted.

In 1955, Gardiner did a survey of malocclusion and some aetiological factors in 1000 Sheffield schoolchildren. He found that 1·6 per cent of the children had congenital absence of one or more teeth, but full-mouth radiography on a large scale was not possible.

Of the nine surveys quoted, three (Werther and Rothenberg, 1939); Brekhus and others (1944); and Sanchez (1964)) give the upper lateral incisor as the most common congenitally missing tooth. The other six state that the lower second premolar is most frequently absent. The present investigation agrees with the latter ranking, with the upper lateral incisors coming well into second place. It is interesting to note that eight out of twelve textbooks which commit themselves on this subject give the upper lateral incisor as the most commonly missing tooth.

Most investigations give a figure of just over 40 per cent for the number of cases with only a single tooth missing, whereas the current survey places the figure higher, at 56 per cent. However, all agree that those cases having one tooth missing, together with those having two missing, make up just over 80 per cent of the cases of partial anodontia.

Dolder (1937) found no differences between the sexes in the general incidence of partial anodontia, but found that missing upper laterals were more common in the female and that the upper premolars were more commonly missing in the male. The present investigation agreed with Glenn (1961) that partial anodontia was more common in the females. It also agreed with Dolder that the upper lateral incisors were more commonly absent in the female. The upper second premolars were marginally more frequently missing in the female in the author's survey. Dolder found that 5 per cent of his cases had a family history of congenitally missing teeth, whereas the present survey showed a figure of 10 per cent.

In a paper to this Society in 1963, Ritchie stated that it is not often that more than four teeth are congenitally missing in any one mouth. In his cases males only were affected. The present investigation showed 15 cases with more than four teeth missing. This represented 0·25 per cent of the population investigated, or 5·83 per cent of the individuals with missing teeth. Of the males with partial anodontia 6·1 per cent were represented in this group and of the females 5·7 per cent.

SUMMARY AND CONCLUSIONS

1. A total of 6000 orthodontic cases were studied with regard to the prevalence of congenitally missing teeth. All patients were radiographed: 4·3 per cent were found to have at least one congenitally missing tooth.
2. The prevalence of congenitally missing teeth was found to be higher in females than in males.
3. The lower second premolar was by far the most commonly missing tooth in the population surveyed. Second in order of ranking was the upper lateral incisor, which occurred more frequently in the female.
4. The distribution of missing teeth between the right and left sides of the arches was remarkably similar.
5. No statistical association was found between individuals with missing teeth and a random sample of the population studied with regard to the distribution within Angle's Classification.
6. The present survey compares reasonably well with other investigations, although the

percentage of congenitally missing teeth is relatively high. This might well be accounted for by the bias of the population towards those children requesting orthodontic treatment, particularly with regard to missing upper lateral incisors.

Acknowledgements

I should like to express my thanks to my partner, Mr. R. J. Sharland, for help in the collection of material; to Dr. J. A. Heady of the Medical Research Council's Social Medicine Research Unit at the London Hospital, for statistical advice; to the Medical Artist and Photographic Department of the London Hospital, for the preparation of the tables and figures; and to the staff of the London Hospital Orthodontic Department for encouragement and advice.

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DISCUSSION

Mr. J. D. McEwen, opening the discussion, asked how Mr. Rose's sample differed from a random sample, and did any bias exist which might influence the results? Mr. Rose said that it consisted of 6000 consecutive patients referred to an orthodontic private practice and who required treatment. This was obviously not a random sample; there were twenty per cent more girls than boys and the patients or their parents were sufficiently interested to seek advice for a malocclusion or the referring dentist felt that the malocclusion would benefit from orthodontic treatment.

There was an abundance of literature on the absence of teeth, but he would only compare Mr. Rose's findings with those of Grahnen who examined a random selection of 1006 children in the range of eleven to fourteen years. Comparison with Mr. Rose's figures showed roughly similar results.

	% *Rose*	% *Grahnen*
Percentage of missing teeth	4·3	6·1
Percentage of mandibular second premolars missing	2·3	2·8
Percentage of maxillary second incisors missing	1·3	1·6
Percentage of maxillary second premolars missing	1·2	1·4

The main difference came in the total frequency of missing teeth between the sexes. Grahnen found no significant difference, but Mr. Rose showed a ' statistically significant ' difference. What was the reason for this? Did Mr. Rose feel this difference might be due to a bias in the sample?

Teeth might be missing for many reasons, but heredity was considered the main factor although there was a difference of opinion on the method of transmission. Some investigators had shown a recessively inherited sex-linked gene, but the accepted theory suggested that a dominant gene was the causal factor. It had been suggested that the reduction in the size of the jaws might be associated with a reduction in the number of teeth following mutations. He asked if Mr. Rose would care to comment on the aetiological background as a result of his finding that only ten per cent had family histories of missing teeth.

Mr. Rose said that the point about the selected sample was that the cases were all referred for orthodontic treatment. That there were more females than males might be a sociological factor in that families were more likely to wish the girls to have better aesthetics than boys.

All kinds of social strata were in the make up of the sample and the vast majority of patients were English born. At the present time, with so much travelling and immigration, it was very difficult, except on an isolated island, to find a true genetic type.

On the reasons for there being more females with missing teeth he did not really have any true concept. It might be that this was related to genetic factors and it came out more in females.

Mr. R. T. Broadway asked Mr. Rose why he used intra-oral radiographs rather than extra-oral ones. This increased the radiation hazard to the child, they were uncomfortable for the child, and the area was not covered so well.

Mr. Rose replied that the radiation hazards were no greater when dealing with the premolar areas and the exposure was about the same. He thought intra-oral films covered the area perfectly adequately and also gave better detail. If one was looking simply for the presence of teeth the extra-oral view was perfectly adequate; but if one was looking at details of morphology, for things like hypoplasia of unerupted teeth and for caries at the same time, intra-oral film would cover all those fields. In a paper elsewhere he had made the point that there was less likelihood of error when using intra-oral X-rays as compared with using extra-oral X-rays.

Mr. E. K. Breakspear said that although the figures were not significant in the numbers given there were more Class III cases than the average that came into this category. He wondered whether Mr. Rose thought there was some kind of association between lack of energy in the growth of the maxilla and lack of energy in the tooth band.

Mr. Rose said that he did not know the answer. Certainly there were more Class III than one would have expected, but he had not done a break down to compare whether the missing teeth in Class III were in the upper or lower arch.

Mr. W. Frankland said that he was sure that many members must have been surprised to find lower central incisors were high on the list of missing teeth. He personally had the impression that sometimes when lower central deciduous incisors were still standing in the arch the lower central permanent incisors had actually erupted distally to them and it was the lower laterals that were missing.

Mr. Rose said that the lower central incisors appeared in the position he had shown, which was fourth in the order of frequency in most investigations. He had not considered the point whether the centrals might be in the position of the lower laterals.

Dr. L. M. Clinch asked whether, when examining the family history of these cases, Mr. Rose had found any connexion in families between missing teeth and supernumerary teeth?

Mr. Rose said he knew that cases had been reported in this way but he had not found any.

Mr. A. J. Walpole Day said that there had been one case of missing lower first permanent molar, in a boy, and one of missing upper first molar, in a girl. He had been taught that the germ of the second molar was developed as an offshoot of the part of the tooth band from which the first molar was developed. While it was possible for one of the series to be missed out, it was unlikely to happen often.

Mr. Rose said he did not know the explanation; it was some kind of accident of development.

The President referred to X-rays of a child taken at eleven years and thirteen years. At the age of eleven, $\overline{|5}$ was absent and at the age of thirteen it was obvious in the X-ray but had not yet erupted. One wondered at what age one could reliably say that a second premolar was absent.

SYMPOSIUM ON ASPECTS OF THE DENTAL DEVELOPMENT OF THE CHILD

1. THE DEVELOPMENT OF THE DECIDUOUS AND MIXED DENTITIONS

LILAH CLINCH, Sc.D., F.D.S. R.C.S., F.F.D., R.C.S.I.

In this paper I am attempting to give a background of the normal for comparison with two aspects of the abnormal which are to follow in this symposium. Any paper on the development of occlusion of the teeth must be based on the work of Hellman (1921) and in more detail on Friel's Occlusion, which he described originally in 1926 and upon which he enlarged in his Northcroft Lecture in 1953. He described the ideal path but Schwartz (1931, 1933), Bonnar (1956, 1960), Sillman (1938), and others have shown that there are many and varied ways of reaching the desired goal and that disproportions in growth and delays in development may present abnormalities which, provided the environment is favourable, may correct themselves. Broadbent (1941) added the foundation to all this work (if a foundation can be added) with his cephalometric radiographs of individual children showing the bone growth which produced the occlusal changes described by other authors.

Friel was the first to demonstrate the fundamental fact that occlusal phenomena obey the general biological principle of continuous change with age, and on the knowledge of this the diagnosis of malocclusion must be based.

During foetal life the relative size of the maxilla and mandible and their relation to each other fluctuate widely. Schultz (1925) represented in diagrammatic form the range of variations up to 14 weeks; he showed a projection of the mandible which at 14 weeks had changed into a projection of the maxilla. Schwartz (1931) showed similar variations. The following illustrations of these variations were shown by me in 1940 from photographs of specimens in the Museum of the Royal College of Surgeons.

Fig. 1A.—A foetus of 56 days showing the mandible considerably larger than the maxilla.

Fig. 1B.—A foetus of 58 days showing a similar condition.

Fig. 1C.—A foetus of 64 days showing more advanced development, with the jaws becoming more uniform in size although there is still a projection of the mandible.

Fig. 1D.—A foetus of 74 days in which the mandibular projection has almost disappeared.

Fig. 1E.—A foetus of 83 days showing a slight projection of the maxilla.

Fig. 1F.—A foetus of 100 days showing a similar relationship.

Fig. 1G.—A foetus of 110 days showing a more marked projection of the maxilla.

Fig. 1H.—A foetus of 5 months showing less projection of the maxilla.

Fig. 2.—A dissection of a foetus near term showing a good relationship of the jaws to each other. This illustration also shows the position of the tongue which lies between the gum pads in all areas until the teeth begin to erupt. Sillman (1938) has shown a lateral radiograph of the head of a living 10-day-old infant with the same opening between the jaws at rest.

When it is realized that from these early stages of development the relationship of the jaws has been changing from one extreme to another it is easy to understand that at birth a relationship may present which is abnormal but which with further growth and favourable environment will correct itself.

At birth the gum pads should meet with the maxillary pads labial and buccal to the mandibular in all areas as the teeth do later. The tongue lies between the pads at rest, but considerable biting and chewing takes place and there is a definite relationship between the upper and lower pads, unlike what is found in an edentulous adult. Practice is needed in finding this relationship so that undue force is not used; this is of great importance as the temporomandibular joint of the newborn child is not such a secure structure as in the adult: there is no articular eminence and the glenoid fossa is practically flat. A glenoid tubercle is present but it is hardly sufficient to prevent dislocation of the jaw, so that the whole articulation depends for its stability on the

Presented at the Country Meeting held at Eastbourne, 21 May, 1966.

Fig. 1.—Radiographs of foetuses. A, 56 days; B, 58 days; C, 64 days; D, 74 days; E, 83 days; F, 100 days; G, 110 days; H, 5 months. (*Reproduced from the ' Transactions of the British Society for the Study of Orthodontics '.*)

strength of the ligaments surrounding the joint. As the molar segments of the gum pads are above the level of the canine and incisor segments it is necessary to use the minimum of pressure when approximating the pads or the molar segments will act as a fulcrum around which the jaw will rotate and the condyle may be drawn out of the shallow glenoid fossa. However, by supporting the whole of the mandible when bringing it into contact with the maxilla it is possible to find the same relationship over and over again. Both gum pads are divided into segments corresponding to the deciduous teeth and these can be used to check the relationship (*Fig.* 3).

As well as a projection of the maxillary arch outside the mandibular at birth there is often a vertical space between the upper and lower incisor segments: this has disappeared at 6 months owing to the swelling of the incisor areas before the eruption of the teeth (*Fig.* 4). A high proportion of infants are born with a markedly posterior position of the mandibular gum pads which may be due to late development (*Fig.* 5). Given a favourable environment this relationship will alter before the teeth erupt, but a finger or lip sucking habit could act as a brake to the anterior movement necessary (*Fig.* 6). The lack of a vertical space in the incisor area may also be a hindrance to the forward positioning of the mandible, though its presence will not insure that the necessary forward movement will take place (*Fig.* 7). Some inherent force seems to be necessary to bring about the constant forward positioning of the mandibular arch in relation to the maxillary arch which occurs from infancy to old age as it may not occur at any stage in the development of the occlusion no matter how good the environment may be.

The first sign of prenormal occlusion of the mandible which I have seen is when the deciduous incisors are erupting (*Fig.* 8), but Schwartz (1931) has shown a dissection of a lower protrusion at birth which he describes as ‘ an incompletely developed newborn which should be considered as a persistence of embryonic inferior protrusion’.

Fig. 2.—Dissection of a foetus near term. (*Figs.* 2, 3 *reproduced from the* ‘ *Transactions of the* 1*st International Orthodontic Congress* ’.)

Sillman (1938) found that the mandibular gum pads were distal to the maxillary in all cases at birth.

To sum up the first stage of the development of occlusion, that is to the relationship of the gum pads at birth, the maxillary pads should project outside the mandibular in all areas just as the maxillary teeth will erupt labially and buccally to the mandibular teeth. But from a much more distal position the mandibular pads may move forwards before the eruption of the teeth, given the right heredity and to a much lesser degree the right environment.

Fig. 3.—Dissection showing segmentation of the gum pads.

At birth, the deciduous teeth in their crypts show a rotation of the upper laterals and of the lower centrals and laterals and there is some imbrication of these teeth. Therefore an increase in the size of the dental arches is needed if the deciduous incisors and canines are to erupt into good alinement, and indeed it is desirable that there should be spacing between the teeth (*Fig.* 9). In underdeveloped jaws the persistence of rotation and imbrication can be seen when the teeth erupt, and even in well formed jaws the rotation can persist in the erupting incisors when the teeth are spaced. In these cases, however, they usually move into good alinement in a few weeks.

In the molar area, unless there is a gross displacement, the shapes of the teeth help to guide them into their correct occlusion. The distal two-thirds of the occlusal surface of the

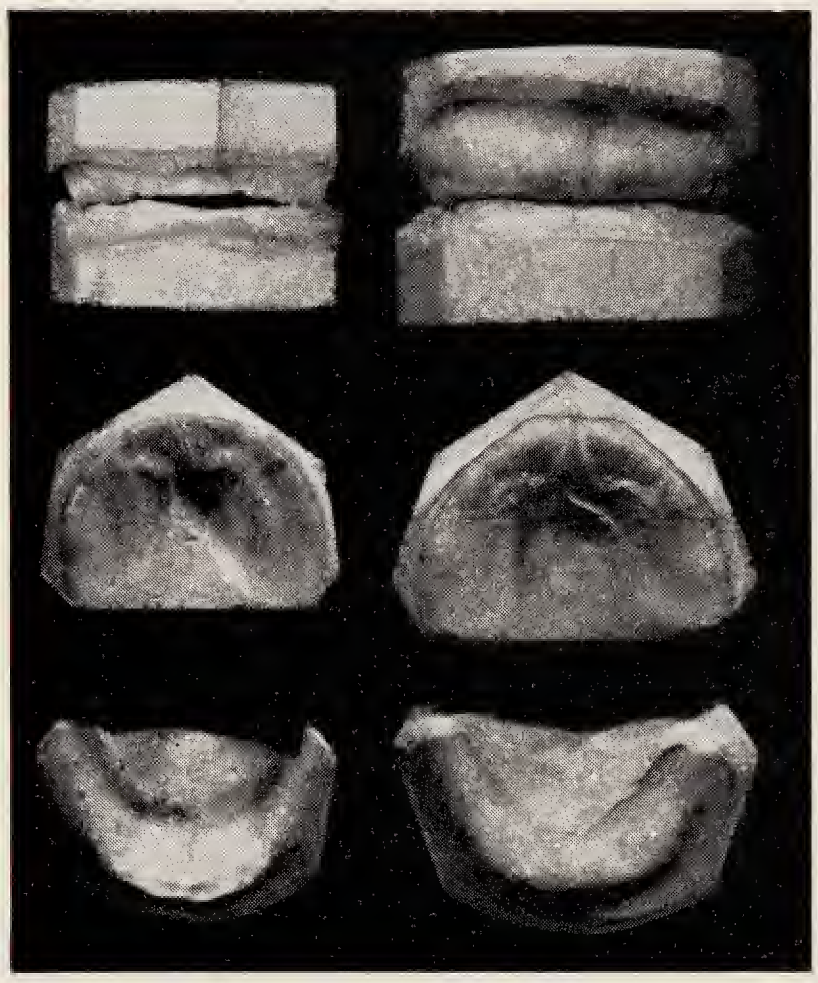

Fig. 4.—Models of the same child at 14 days and at 7 months. (*Figs.* 4–7 *reproduced from the 'Transactions of the European Orthodontic Society*.')

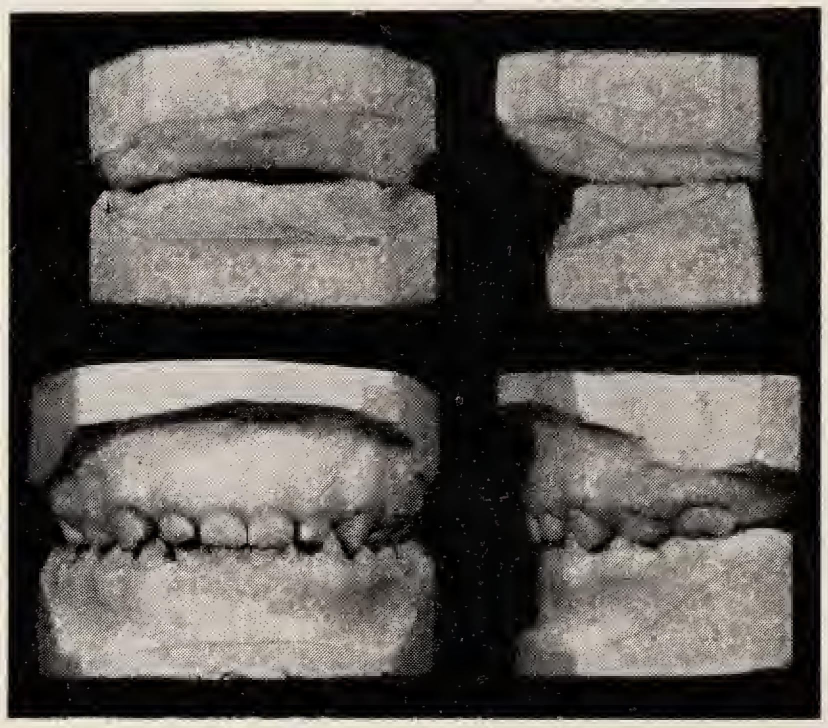

Fig. 5.—Models of the same child at 21 days and 3 years, 4 months, showing a posterior position of the pads which develops into good occlusion.

Fig. 6.—Models of the same child at 14 days and at 2 years, 8 months. No vertical space in incisor region and posterior position of mandibular pad. This posterior position persists and the occlusion shows a postnormal mandible with a narrow maxillary arch. This child was a persistent thumb sucker.

Fig. 7.—Models of the same child at 12 days and 3 years. Posterior position of the mandibular gum pads with vertical space in incisor region. The posterior position of the mandible persists when the teeth erupt.

lower first molar is occupied by a large fossa of which the sides are very steep. This tooth erupts before the upper molar, the most prominent part of which is the large mediolingual cusp, and if this engages on any part of the fossa of its protagonists it is guided into its correct position as the tooth continues to erupt. The same thing occurs with the second molars. However, cases are seen where the lower first molar has erupted too far forwards to engage the cusp of the upper tooth. This is usually a unilateral condition and if it persists it can result in a deviation of the lower centre line towards the opposite side so that the entire occlusion can be displaced. It can correct itself when the second molars erupt, but if it does not it is one of the causes of the deviation of the midline which can be seen in the permanent dentition in cases where there have been no premature extractions. The large cusp and deep

fossa lock, however, explains why an anteroposterior malocclusion is more common than a lateral one, especially in the deciduous dentition. Schwartz (1933) has shown one case where the upper molars were completely buccal to the

Two major changes are necessary in the transition from the deciduous to the mixed dentition. First, a change in arch relationship to allow the first permanent molars to erupt into correct occlusion, and, secondly, growth in both arches

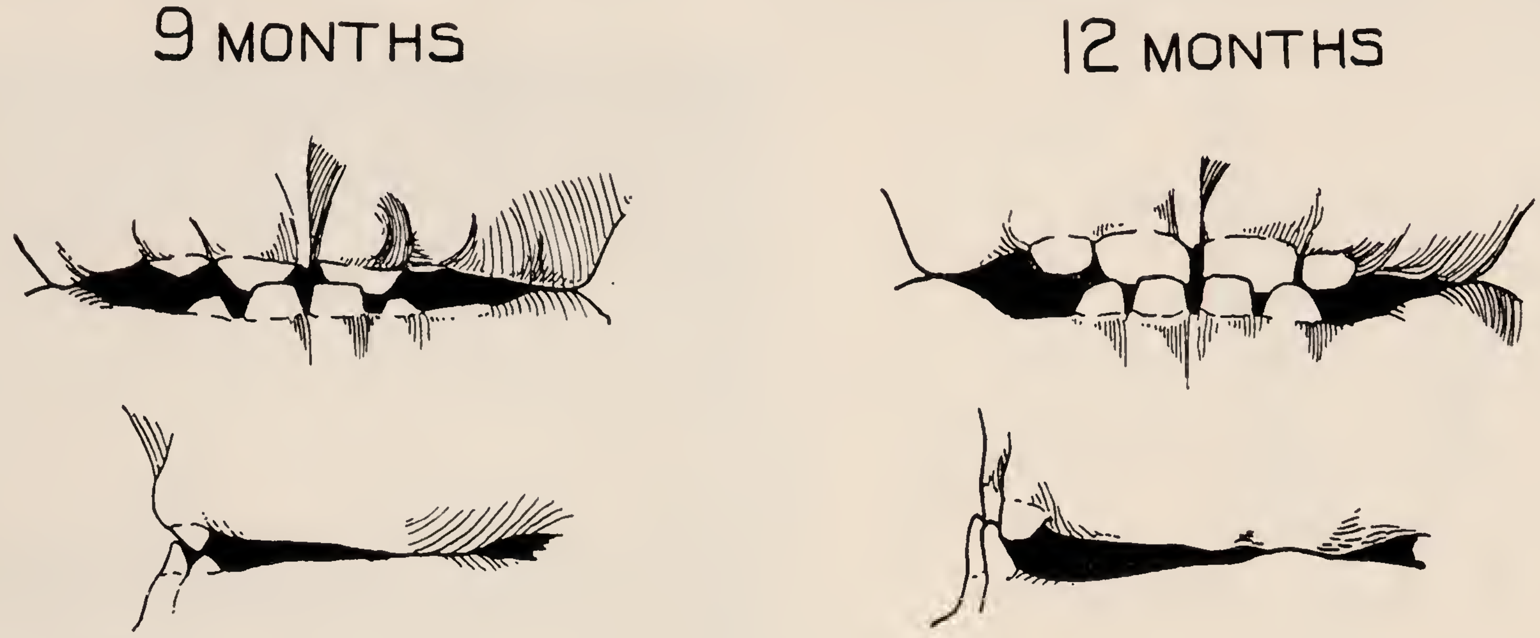

Fig. 8.—Drawings showing the eruption of the maxillary incisors lingually to the mandibular incisors.

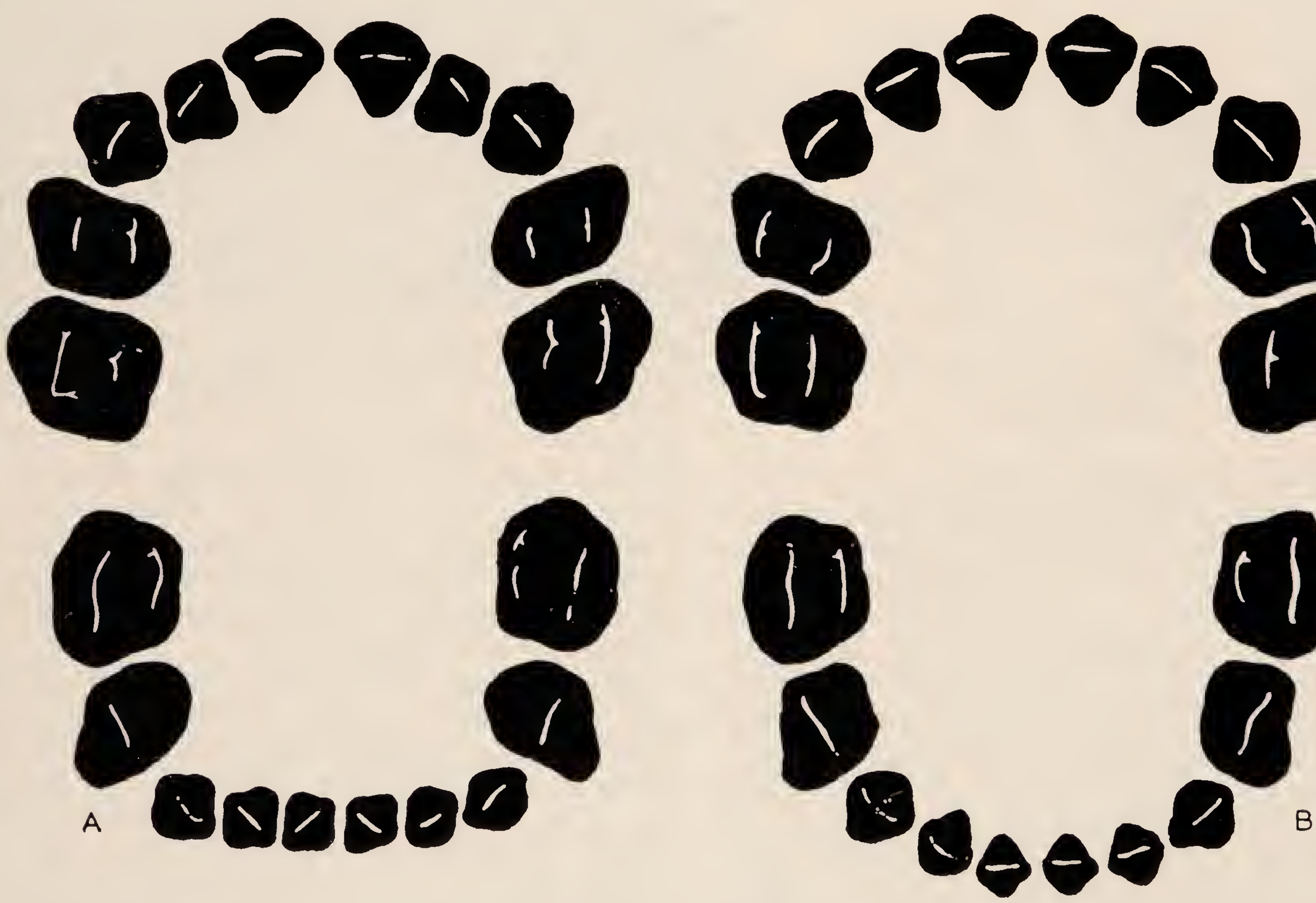

Fig. 9.—A, Before birth, showing the position of the deciduous teeth in their crypt. B, At 3 years, showing the increase in the size of the arches to accommodate the deciduous incisors in correct alinement. (*Figs.* 9–12 *reproduced from the ' Transactions of the British Society for the Study of Orthodontics '*.)

lowers in a case of normal anteroposterior arch relationship, and he has given as the cause a buccal inclination of the maxillary molar germs with possibly a lingual inclination of the mandibular germs. Fortunately for the clinical orthodontist this condition is very rare in the deciduous dentition.

to accommodate the larger permanent incisors. Chapman (1928) was the first to demonstrate that immediately after their eruption the distal surfaces of the second deciduous molars end off flush because the mandibular second molar is larger mediodistally than the maxillary tooth. Friel (1953) described this as the correct occlusion

for three years of age and explained that a forward movement of the lower arch must take place during subsequent years if the first permanent molars are to erupt into their correct occlusion. Bonnar (1956) showed cases where the occlusion of the second molars at three years was already in the position described by Friel as ideal for the period immediately prior to the eruption

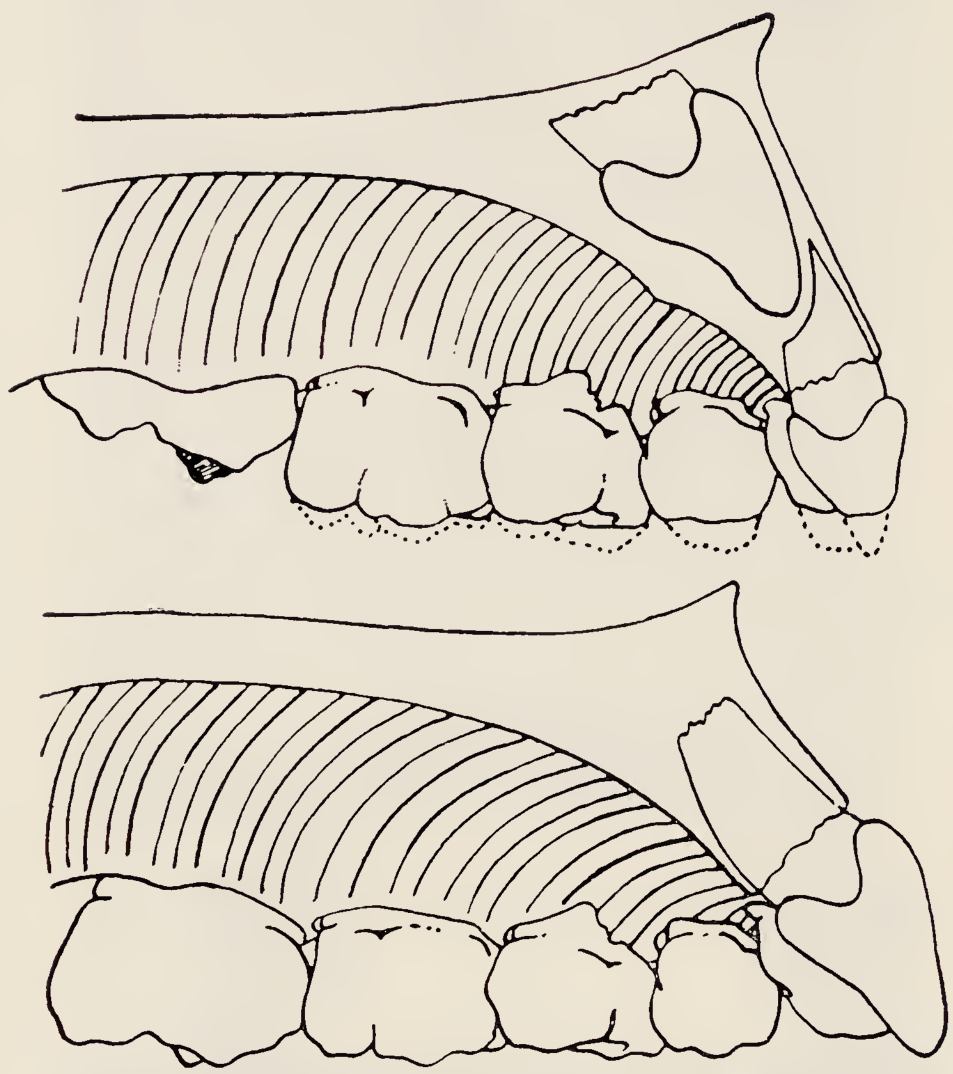

Fig. 10.—Difference in inclination of the deciduous and permanent incisors.

of the first permanent molars. A possible explanation of these cases is that there is less difference between the mediodistal diameters of the upper and lower second deciduous molars. Where a change of arch relationship is needed to allow the first permanent molars to erupt into correct occlusion, Friel (1926) has stated that the cusps must be worn down to eliminate the locking of the teeth. But Baume (1950) and Bonnar (1960) showed that this change in anteroposterior arch relationship can occur without attrition and it would seem that the only explanation of this is that the cusps are flatter and the fossae less deep so that the locking is not so firm in these cases. All agree, however, that, as in the gum pads, whether or not this forward movement of the lower arch takes place depends on some inherent force which can even overcome adverse environment, though when the forward movement does not take place it is sometimes difficult to say how much the environment can be blamed. Even with what appears to be a completely favourable environment the forward movement of the lower arch may not occur.

Seipel (1946) has given the average difference between the mediodistal diameters of the crowns of the deciduous and permanent incisors as, in the maxilla, 7·18 mm., and in the mandible, 5·06 mm. Prior to the eruption of the permanent incisors a small increase in the intercanine breadth in both arches occurs (Clinch, 1951) but the greatest increase takes place during the eruption of the central and lateral incisors. In the upper arch there is no significant difference between the increase in the inter- and extracanine breadth, but in the lower arch the difference is significant between the increase in the extracanine breadth and the intercanine breadth, and it appears that there must be an increased labio-inclination of the lower canines. Space is also made in both arches by the greater labial inclination of the permanent incisors (*Fig.* 10). According to Seipel (1946), the upper incisors are, on average, 2·12 mm. wider than the lower. Therefore the maxillary arch must provide this extra mediodistal tooth space to form the mixed dentition. This it does in three ways: (1) By growth in the upper incisor area, which may result either in crown or root spacing of the deciduous teeth; (2) By greater arch expansion in the maxilla; (3) By greater labial inclination of the upper permanent incisors.

Slight growth in the upper incisor area takes place before the shedding of the deciduous teeth. It may result in slight spacing of these teeth or spacing of the roots which I think is more common and is due to growth of the alveolus holding the incisors. Measurements on serial models show that the angle of the labial surface of the upper central to the incisor–second molar plane increases with age so the apices of the teeth must diverge (*Fig.* 11). The rate of expansion in the upper arch is greater than in the lower, especially during the eruption of the permanent incisors, and the forward movement of the lower arch which is taking place at this period enables the larger upper arch to continue to occlude with the lower.

As the upper permanent incisors grow down their direction of eruption is much more labial than the deciduous incisors so that they form a wider arc of a circle; this also helps to produce the extra tooth space which is necessary. It is at this period that the lateral incisors, which in the majority of cases lie lingual to and partially overlapped by the centrals before eruption, are enabled to move into alinement (*Fig.* 12). Bonnar (1960) has shown how the upper permanent incisors may start to erupt in an almost vertical direction and only acquire the labial inclination as the teeth erupt further. I suspect that these cases would show at an earlier stage a high rate of alveolar growth in the incisor area, with probably marked spacing of the deciduous incisor roots, so that the permanent incisors are moved bodily forward and only later tilt labially.

From the clinical point of view it is well to remember that the upper permanent central incisors erupt spaced, sometimes widely spaced; they have developed spaced probably because of the septum between the two halves of the maxilla. The eruption of the lateral incisors usually closes

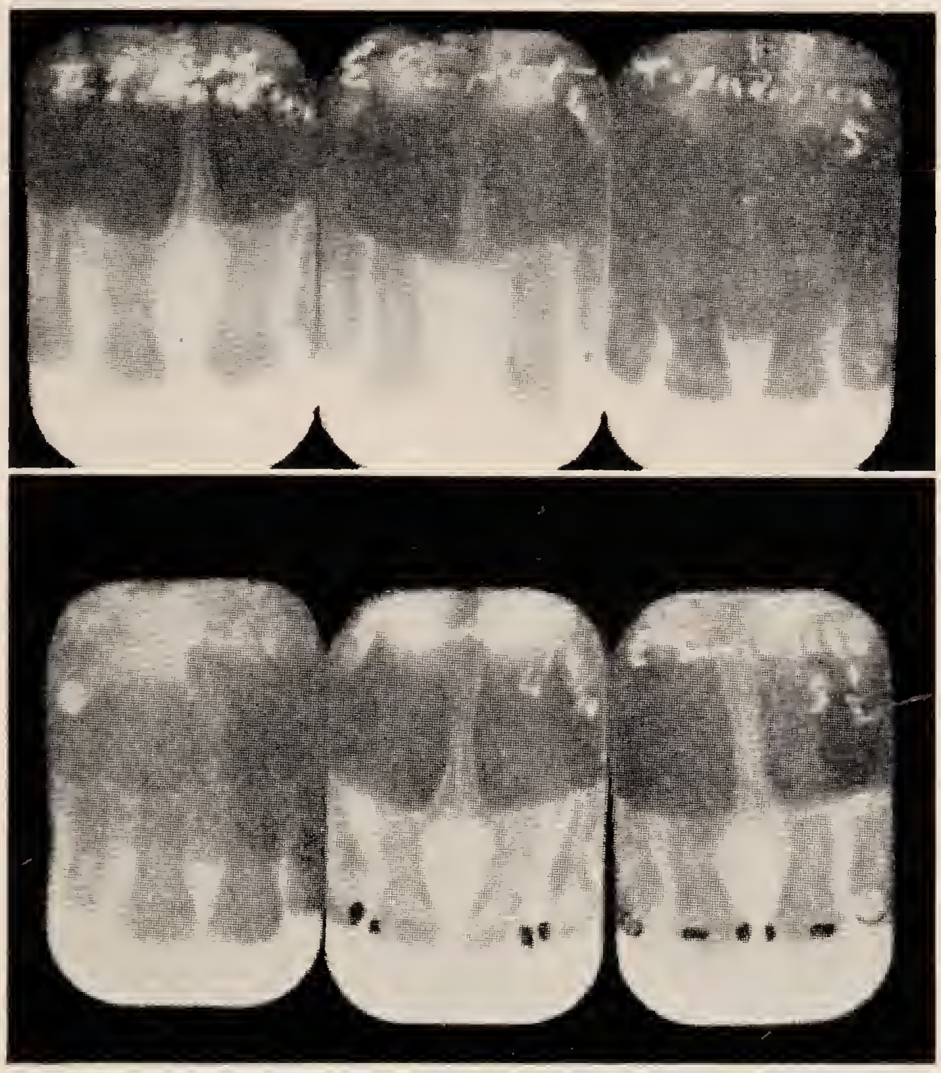

Fig. 11.—Radiographs showing two types of spacing of deciduous incisors: crown and root spacing, and divergence of roots.

this space though it may not close entirely until the canines erupt.

In under-developed arches it is common to see the upper lateral incisors lingual to the central and imbricated, in fact in the normal positions for an earlier stage in the development. One can also see well-developed arches with no imbrication but showing, nevertheless, rotations and malpositions of the incisors, so the size of the arches does not in every individual determine whether the teeth will be regular or not; though in the great majority if there is space the teeth will be straight eventually, even if there is some irregularity as they erupt.

To summarize the development of the deciduous and mixed dentitions, a series of tracings is shown of the developing dento-facial pattern of a normal child from 1 month through 9 years published by Broadbent (1941) (*Fig*. 13). At 1 month the jaws contain the partially calcified crowns of the 20 deciduous teeth and the crypts of the first permanent molars; the arrangement of the dental units approaches closely to their subsequent pattern when these teeth reach their full functional occlusion. By 9 months the increase in the size of the teeth is accompanied by the cutting of the incisors into the mouth and the beginning of calcification of the upper and lower permanent centrals and lower laterals. Three months later, at 1 year, when the first

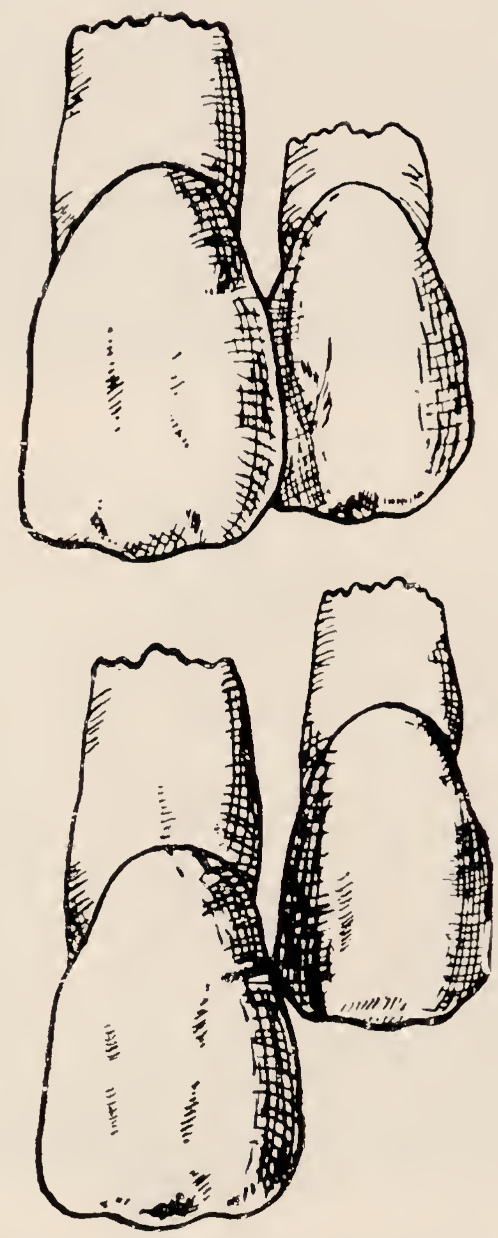

Fig. 12.—Diagram showing how, as the central incisors erupt, the lateral incisors escape from behind them, and can erupt downwards and forwards.

deciduous molars are appearing in the oral cavity, the roentgenogram reveals the beginning of calcification of the permanent canines between the roots of the first deciduous molars. As the deciduous teeth erupt towards the occlusal plane the incisor and canine crypts, including their rapidly growing crowns, migrate forward in the jaws at a greater rate than the deciduous teeth; these changes are easily gauged in relation to the relatively fixed Frankfurt Po.–Or. and orbital planes Ao in *Fig*. 13.

At $1\frac{1}{2}$ years the upper lateral incisors begin their calcification at sites partially behind the upper centrals and below the upper canines. Not until $2\frac{1}{2}$ years do the first premolars begin their calcification between the roots of the first deciduous molars, in fact the site of origin of these teeth is the same as that of the permanent canines at one year. This occurs when the child

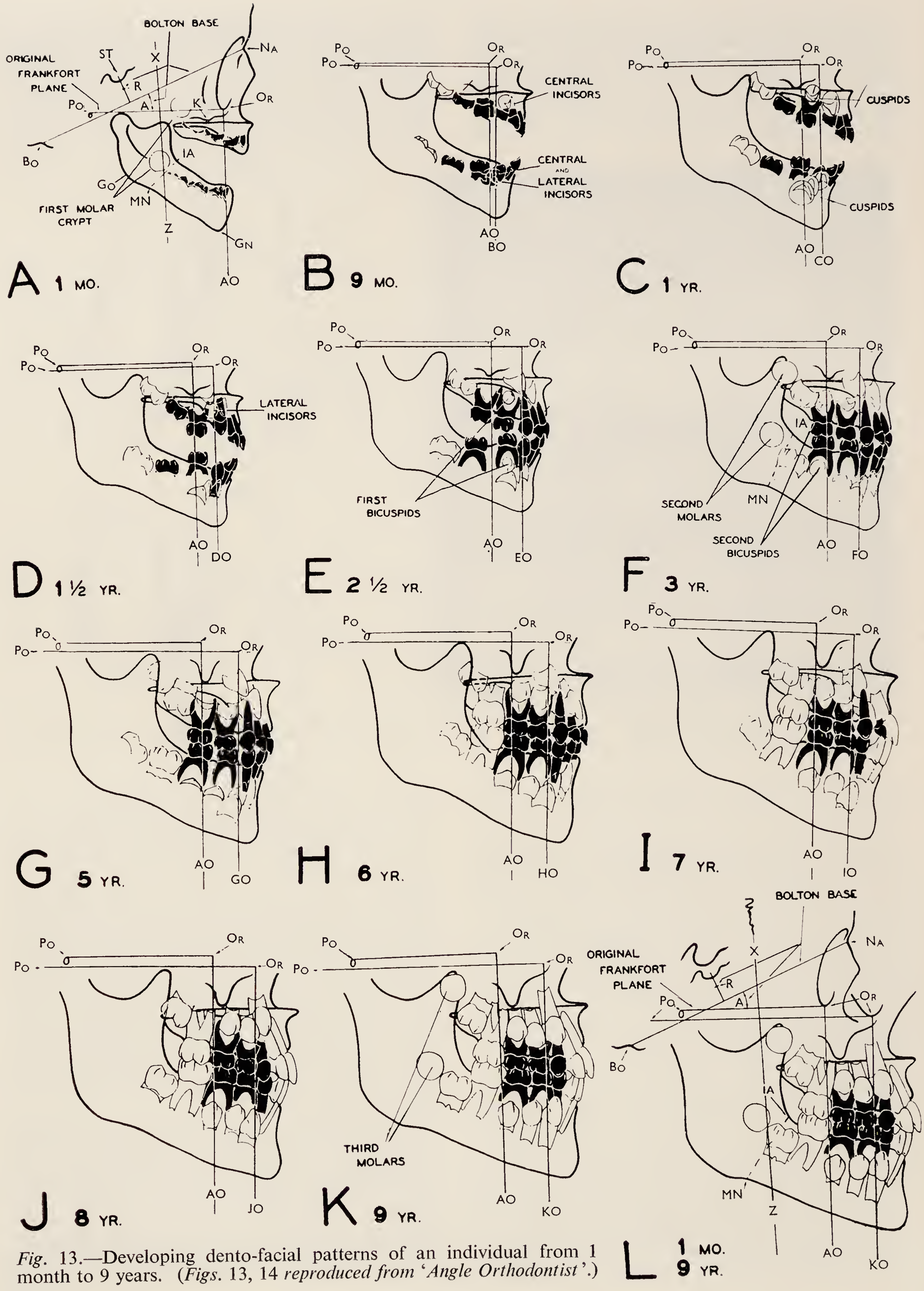

Fig. 13.—Developing dento-facial patterns of an individual from 1 month to 9 years. (*Figs.* 13, 14 *reproduced from 'Angle Orthodontist'.*)

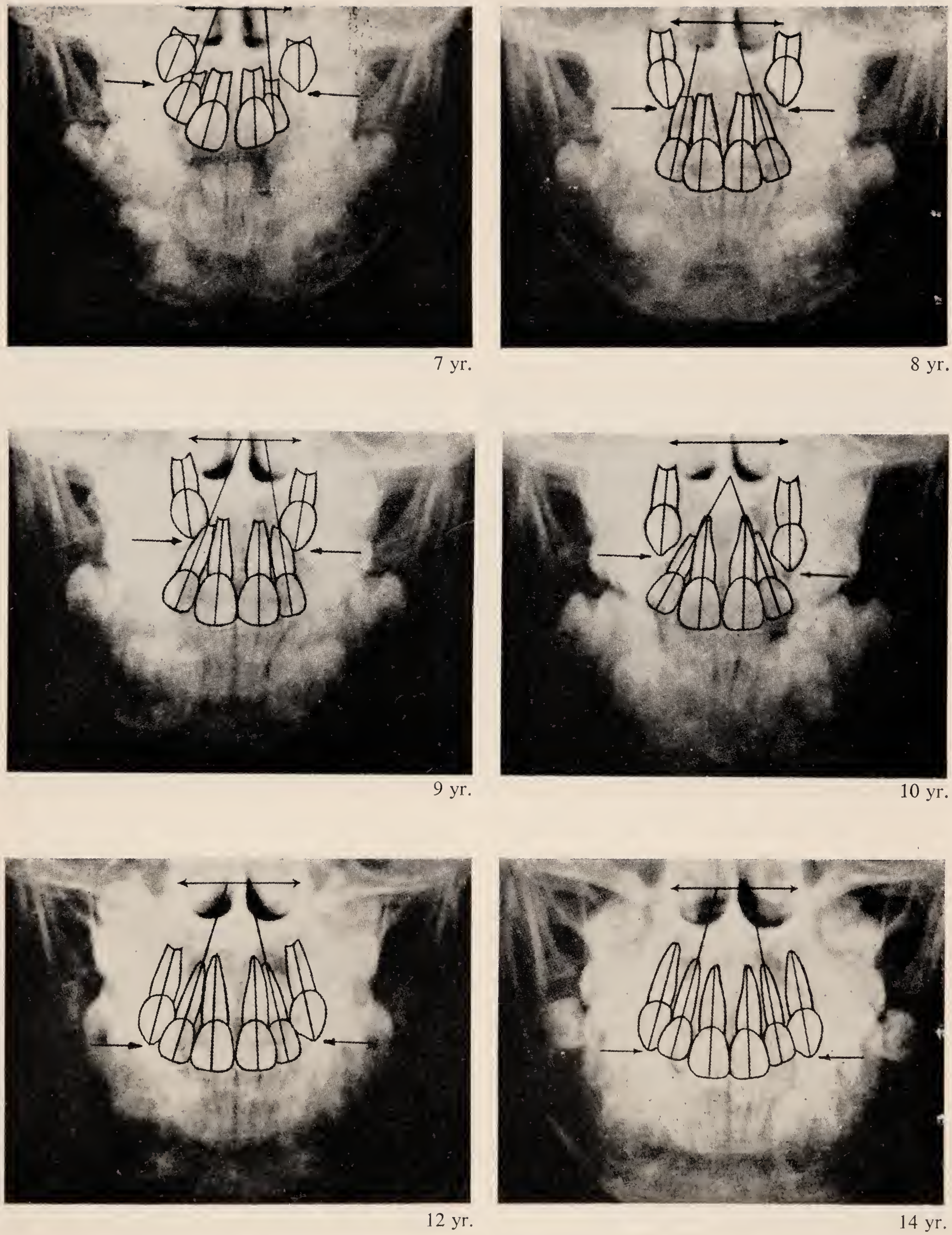

Fig. 14.—Frontal dental patterns from an individual showing normal axial changes of erupting incisors and canines during the ' ugly duckling ' stage of developmental growth in the mixed dentition.

is cutting the last of the deciduous molars to complete the clinical pattern of the deciduous dentition. The rapid growth of the jaws continues and by the 3rd year the crowns of the four first permanent molars are completed, while the lower first molars have migrated from their site of origin downwards and forwards into the body of the mandible, from which point they will be seen in the following tracings to change their course to an upwards direction to cut their way into the mouth. During this eruption these teeth, like all teeth in the face, are being carried downwards and forwards and outwards as the face widens, but at a slower rate than the rate of eruption; only the central incisors maintain their proximity to the median plane.

Three years of age also shows the appearance of the beginning of calcification of the second premolars between the roots of the second deciduous molars and also the calcification of the second permanent molars, so that with the completion of the deciduous dentition there are within the jaws the calcifying crowns of all the permanent teeth except the third molars. By 3 years of age the pattern of the face as a whole has been completed and undergoes little if any change in configuration thereafter. By the 5th year (*Fig.* 13G) the crowns of the permanent upper and lower laterals have been completed. Before the 5th year resorption of the roots of the deciduous incisors has started. In the 6th year we find the clinical dental pattern at the onset of the mixed dentition with the 20 deciduous teeth augmented by the four first permanent molars. The jaws continue their rapid rate of growth to accommodate the fast advancing permanent teeth.

Broadbent (1941) emphasizes that, unlike the usual description of tooth eruption by apposition at the root end that is believed to force the crowns towards the plane of occlusion, his serial studies on living children clearly show that a tooth at various times may progress in three different ways. First the growing tooth may remain stationary while its forming end grows away from the incisal or occlusal surface in the bone; secondly, at another time it may migrate relatively rapidly through the bone but with little increase in its length; thirdly, the increase in tooth length and the migration of the tooth through the bone may occur simultaneously.

The completion of the deciduous occlusion covers a period of 3 years. It maintains its occlusal function intact for a like period of time when it is joined by the first permanent molars shortly before the shedding of the deciduous teeth begins. This shedding covers a period of 6 years when these teeth are replaced by their permanent successors.

The arrangement of the permanent teeth within the bone just preceding the eruption of the incisors is very complicated. The closely packed crowns of the 28 permanent teeth are cramped in the jaws at this age. By the 7th year the crowns of the permanent canines have been completed, but they have not yet moved far from their site of origin. In a relatively short time the incisors cut their way into the mouth with an increased inclination, especially in the maxilla, which helps to accommodate these larger teeth. The growth process slows down between 7 and 10 years and it is this period which Broadbent (1941) has described as the ' ugly duckling ' stage. Since the crowns of the permanent incisors reach their adult size before they erupt they appear on eruption to be too big for the juvenile mouth. This stage when viewed from the frontal aspect (*Fig.* 14) shows the large centrals erupting with a separation at the midline. The upper laterals as they erupt move from behind the centrals and the space between the centrals closes. The growth in lateral dimensions of the supporting structure, especially the area at the level just below the floor of the nose where the canines are developing, is relatively slower, which forces the laterals into a fan-shaped pattern which increases until there is sufficient lateral growth in the apical base to hold the teeth in a more erect position and the increase coincides with the eruption of the canines. It is during this ' ugly duckling ' stage that care must be taken not to confuse a malocclusion with the minor irregularities which may occur during quite normal development, but on the other hand it is also at this stage that a definite diagnosis of malocclusion should be possible.

In conclusion I hope that the work of Friel and Broadbent, which I have freely quoted, demonstrates that despite its complication there is an orderly progress taking place during the development of the occlusion and the knowledge of this is the first and most essential part of orthodontics.

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2. THE EARLY DEVELOPMENT OF CROSS-BITES

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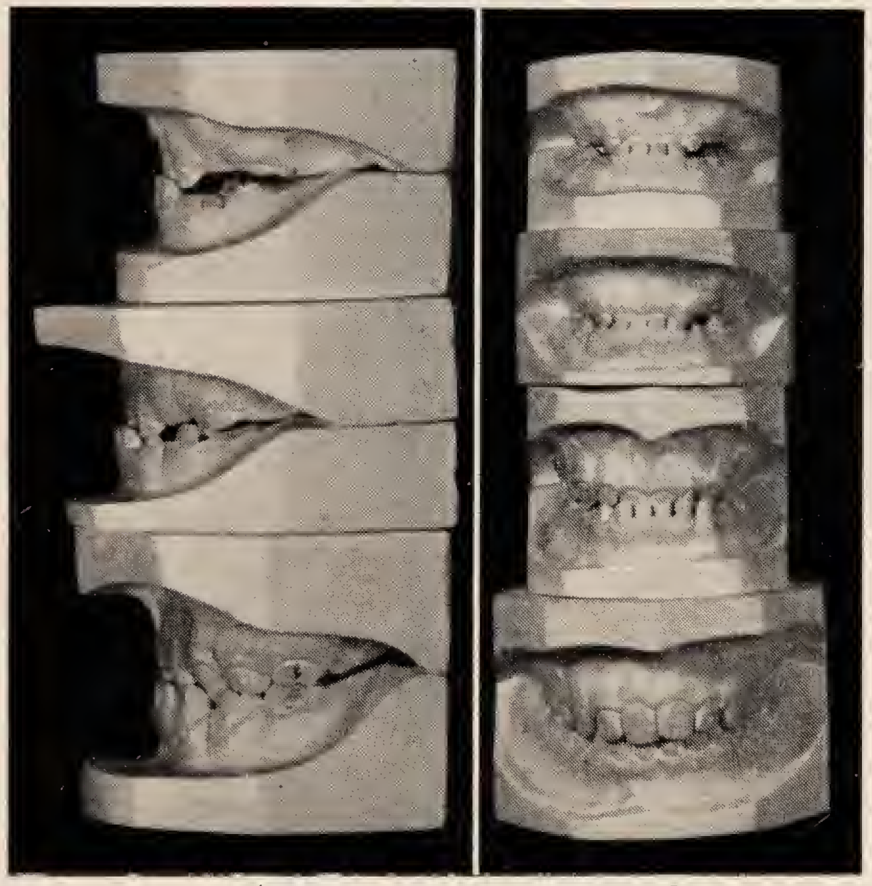
It was in 1910 that Northcroft drew the attention of this Society for the first time to the existence of malocclusion in the deciduous dentition. Since that occasion the works of Chapman (1924), Friel (1938), Clinch (1951), and Sillman (1951) have enlarged our knowledge of dental occlusion at this age period. There is no one now who doubts that malocclusion can manifest itself in the deciduous dentition. However, little is known of its significance, and predictions based upon observations at this age are still very uncertain. For this reason, it is felt that longitudinal studies are required to correlate malocclusion of the deciduous dentition with subsequent development of the permanent dentition. It is from a sample collected for this purpose that the material for this paper has been drawn. Since the subject is far too vast to be covered in a short paper and most of the work is in any case uncompleted, only one aspect of the subject has been selected, namely buccolingual malrelations of the posterior teeth. This includes both cross-bite (lingual occlusion) and buccal occlusion of upper teeth.



A B

Fig. 1.—A cross-bite affecting the first deciduous molars is due to the prenormal occlusion. Correction of the incisor relation with an appliance at 9 years may have contributed to resolution of the cross-bite.

Of 550 cases originally seen, only 120 are still under observation. Of these 24 had some abnormality of buccolingual relation of the deciduous teeth: 19 cross-bites and 5 buccal occlusions of upper molars. In order to make comparisons of longitudinal dimension records, those cases with complete records at yearly intervals were selected as controls. Only 36 cases had such records, the remainder having failed to attend one or more visits within four months of the anniversary date.

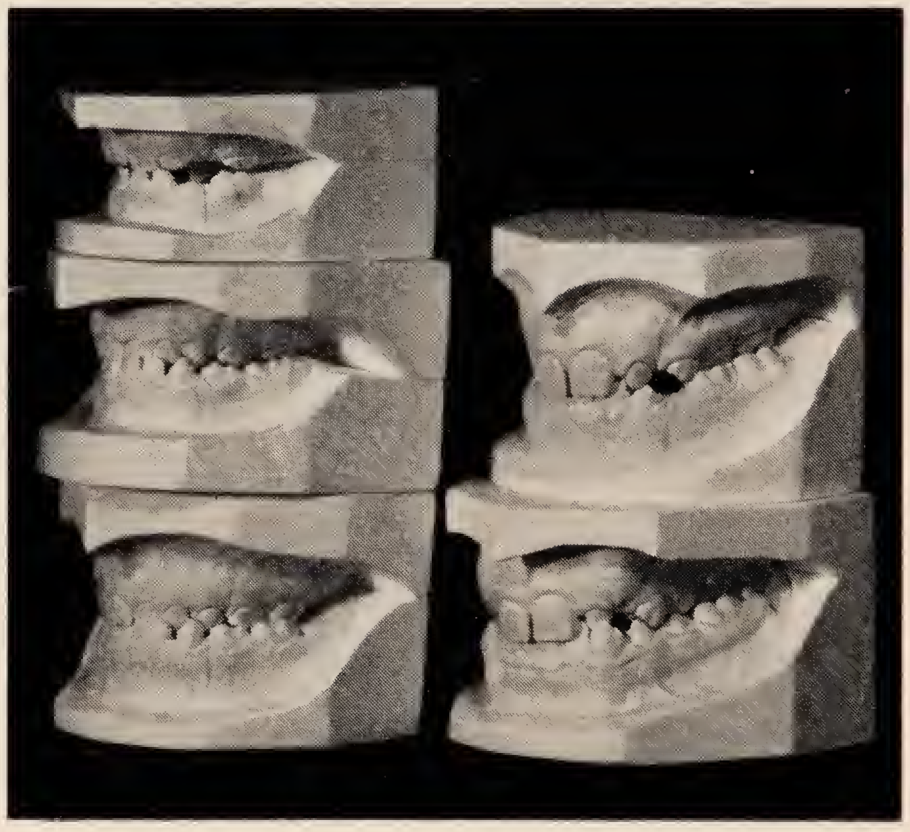


Fig. 2.—An untreated prenormal occlusion in which lingual occlusion of the upper molars and premolars persisted.

Cross-bites may arise as a result of a skeletal discrepancy or of an unfavourable balance of force causing lingual inclination of upper teeth or buccal inclination of lower teeth. The skeletal discrepancies may take the form of a prenormal relation of the apical bases or of a disproportion of width. Three cases of prenormal occlusion and another two with mild prenormality were found among the cross-bites. An example of prenormal occlusion in which a cross-bite developed at an early age is shown in *Fig.* 1A. It will be noted that lingual occlusion of the upper incisors was present before eruption of the canines. This case was treated by labial movement of the upper incisors at the age of 9 years, and the cross-bite did not persist into the

permanent dentition (*Fig.* 1B). In another case (*Fig.* 2), although the development of the cross-bite occurred rather later, a prenormal relation of the jaws was apparent almost from birth.

Both of these examples show how a prenormal relation encourages a cross-bite. They also demonstrate how the prenormal incisor relation is established as soon as the teeth erupt. It has been said that the canines are responsible for precipitating a forward path of closure, and by others that early loss of the deciduous molars encourages this. A number of examples of prenormal occlusion has been seen in this series; in every one the incisor relation was prenormal at the time of their eruption.

A

B

Fig. 3.—Unusual narrowness of the deciduous arches persisted only in the upper arch to change a mild unilateral cross-bite into a bilateral cross-bite.

In the third case the width of both arches was well below the mean for the controls (*Fig.* 3A). Although there was a mild degree of prenormality, the mutual discrepancy between the two arches increased with age and was largely responsible for the bilateral cross-bite which developed (*Fig.* 3B). As might be expected cross-bites of skeletal origin were rarely resolved without treatment. This is not true, however, of cross-bites arising from an imbalance of force, 6 of which were eliminated when deciduous teeth were replaced (*Table I*).

An imbalance of buccolingual forces before the age of 5 years is most likely to be caused by sucking habits, which at this stage can be indulged for long periods of the day as well as the night. Among the controls 9 cases (25 per cent) were found not to have had a sucking habit at all, whereas only two of the cross-bite cases never indulged (*Table II*). Both of these were prenormal. Examination of cine film records gave no reason to think that orofacial muscular behaviour was an important factor in the initial aetiology of cross-bites. Examination of lateral skull radiographs showed a similar distribution of variations of tongue position in the two groups. Comparison of records at birth revealed very little difference between the two groups. The cross-bite cases were a little heavier than the controls and unexpectedly showed less asymmetry of the jaws (*Table III*).

Measurements of arch width had been made on the study models of each child at yearly intervals. These were measured as the external and internal intercanine and intermolar widths of each arch. The former were measured at the

Table I.—Distribution of Cross-bite Cases according to the Site of the Cross-bite at 67 and 139 Months

Site at 67 Months	Site of Cross-bite at 139 Months			
	No c'bite	C'bite left	C'bite right	C'bite bilat.
C'bite left	4	2		1
C'bite right	3	1	5	1
C'bite bilat.				2

gingival margin at the centre of the cingulum and the most bulbous part buccally, and the latter gingivally at the lingual and buccal fissures of the molars. In addition, measurements were made of arch width between points on the lateral sulci both externally and internally. These have been described in a previous paper (Leighton, 1960a). This made possible comparisons from birth before eruption of the teeth. Graphs were prepared from the means of each dimension at yearly intervals, comparing the cross-bite cases with the controls. No differences between the

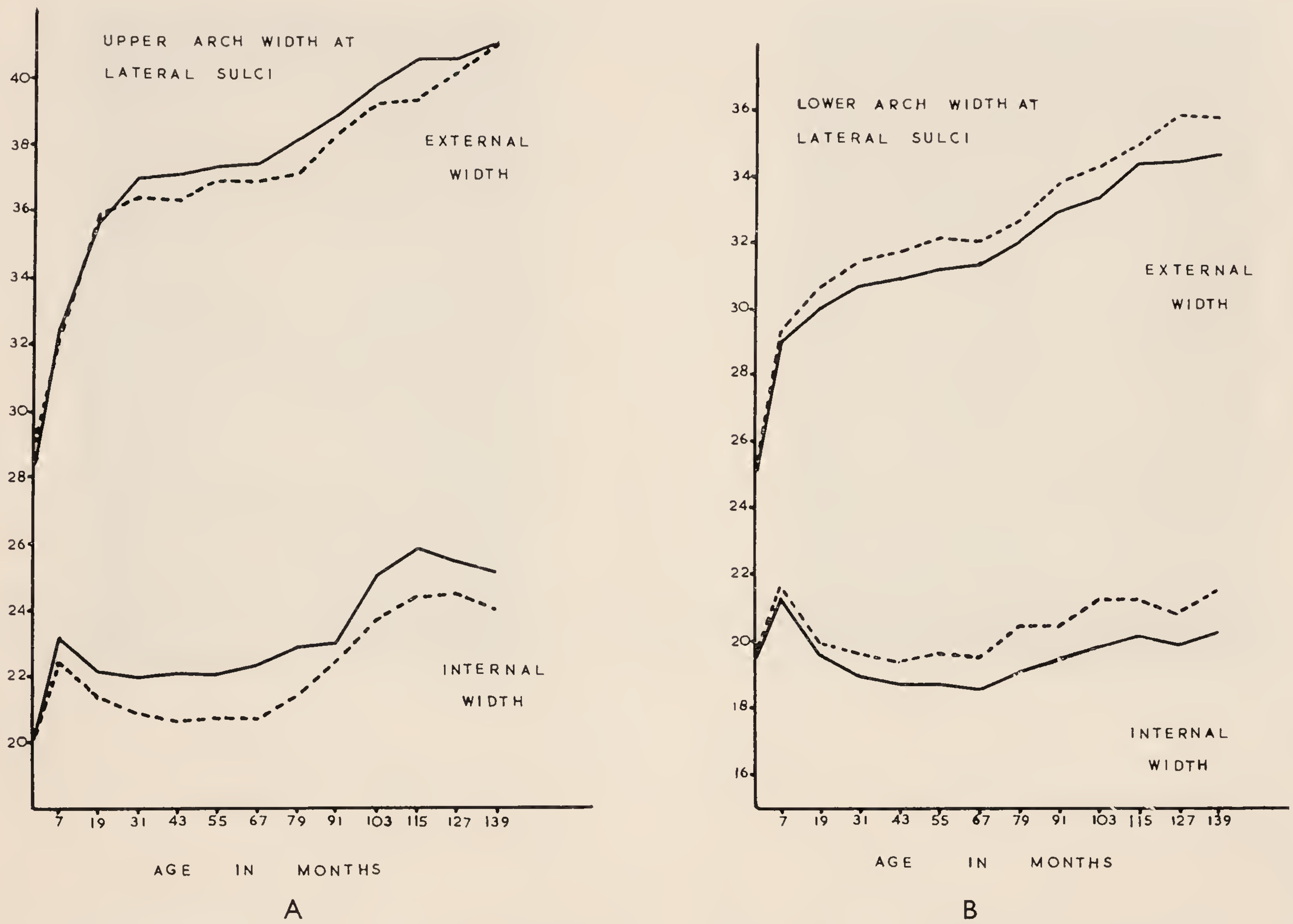


Fig. 4.—Graphs plotted at yearly intervals, from the mean widths in millimetres, of the alveolar arches at the outer and inner ends of the lateral sulci. The solid lines represent 36 control cases and the dotted lines 19 cross-bite cases. A, Upper arch; B, Lower arch.

Table II.—Distribution of Cases according to the Duration of Sucking Habits

Duration of Habit	Controls	Cross-bite Cases	Buccal Occl. Cases
None	9	2	
Less than 3 years	11	6	5
More than 3 years	16	11	

Table III.—Distribution of Cases according to Symmetry of the Gum Pads at Birth

Symmetry	Controls	Cross-bite Cases	Buccal Occl. Cases
Yes	25	17	3
No	10	2	2
Not known	1		

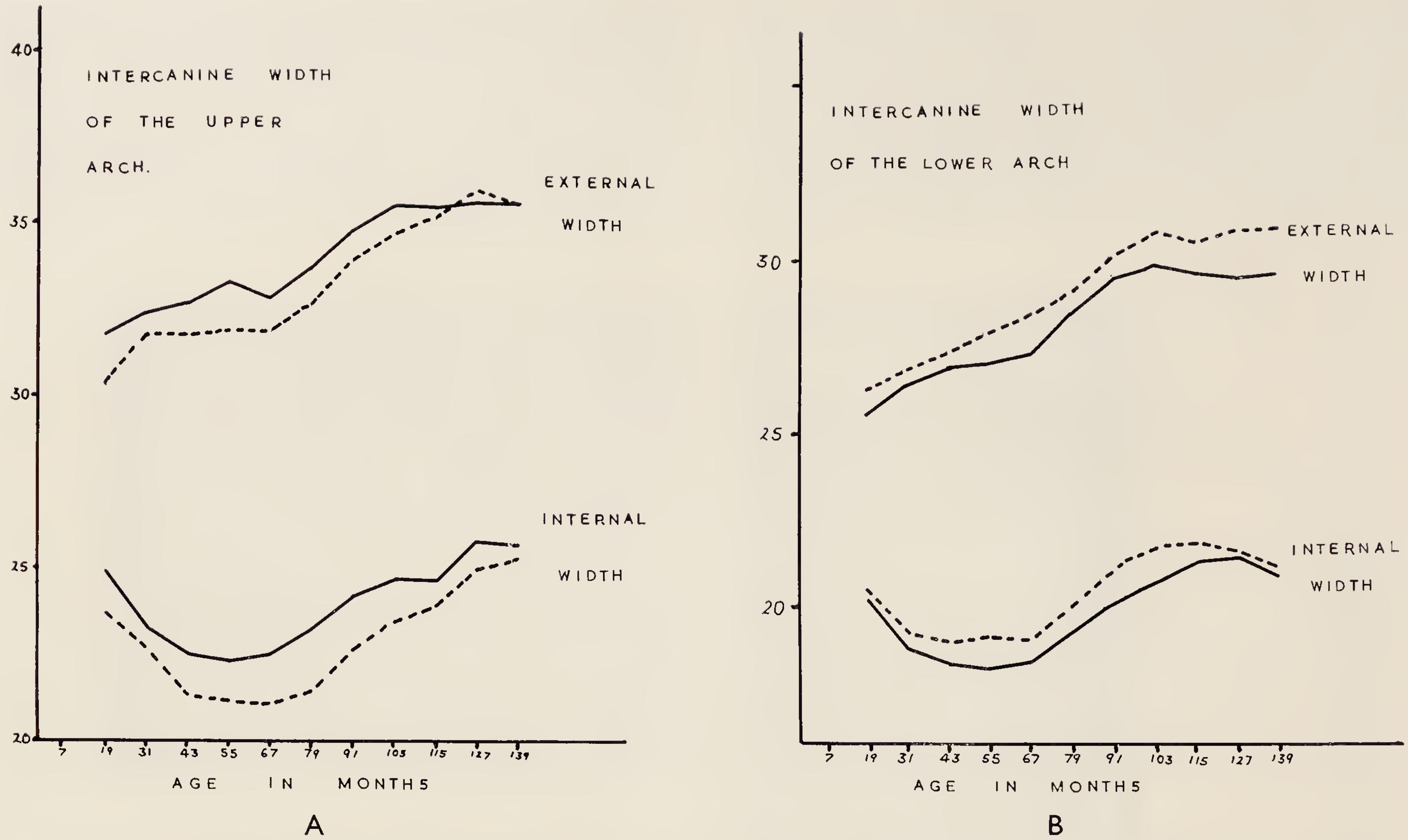


Fig. 5.—Graphs plotted at yearly intervals, from the mean widths in millimetres of the outer and inner intercanine widths. The solid lines represent 36 control cases and the dotted lines 19 cross-bite cases. A, Upper arch; B, Lower arch.

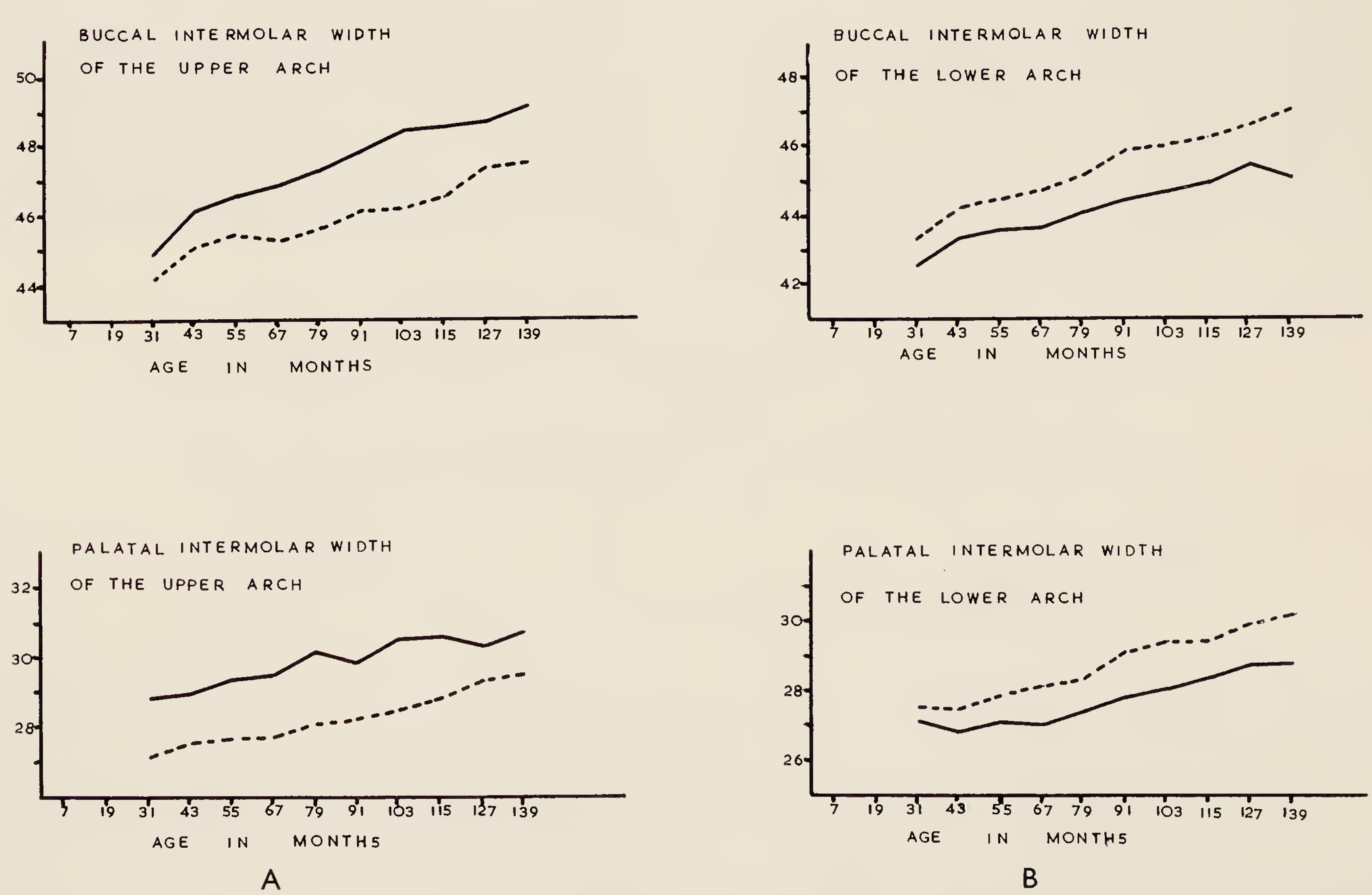


Fig. 6.—Graphs plotted at yearly intervals, from the mean widths in millimetres of the outer and inner intermolar widths. The solid lines represent 36 control cases and the dotted lines 19 cross-bite cases. A, Upper arch; B, Lower arch.

two groups became apparent before the age of 7 months (*Fig.* 4). It is interesting to note that the discrepancy is greater in the palate than externally, and to speculate whether this reflects a lack of outward pressure from the tongue during thumb or finger sucking. It was found with all measurements of width that not only did the upper arch become narrower but the lower arch became wider in the cross-bite cases (*Figs.* 5, 6). The early age at which this difference in the lower arch appeared suggests that it is not a secondary effect of the cross-bite, but rather arises from the same cause as the narrowness of the upper arch. However, the cross-bite cases were slightly heavier than the controls at birth and this advantage had been increasing up to the present. The controls had a mean weight at birth of 7·4 lb. (S.E. $\pm$0·154), and the cross-bite cases a mean weight of 7·7 lb. (S.E. $\pm$0·153). By 10½ years the mean weights were 77 lb. (S.E. $\pm$2·85) and 85 lb. (S.E. $\pm$1·35) respectively. These differences were not quite statistically significant at the 5 per cent level, but might have been had the sample been larger. It is not unlikely that the differences in overall size of these children contributes to the larger lower arch. It should be remembered, however, that a small weight differential was present at birth before any arch discrepancy appeared. Very few of the cross-bite cases became postnormal, and they included all the prenormal cases (*Table IV*).

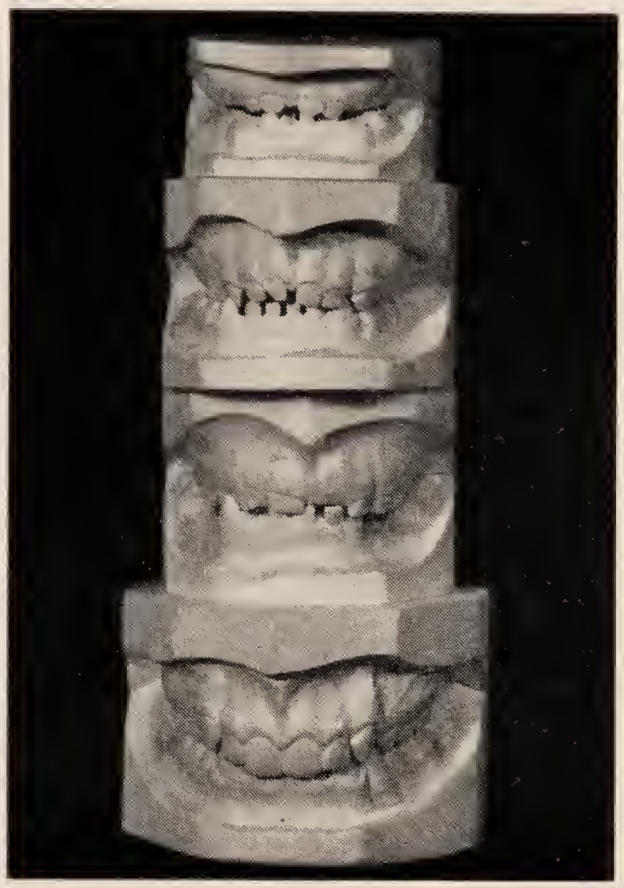


Fig. 7.—This case shows how development of a cross-bite is accompanied by mandibular displacement to the right. Both were resolved spontaneously when the deciduous teeth were replaced.

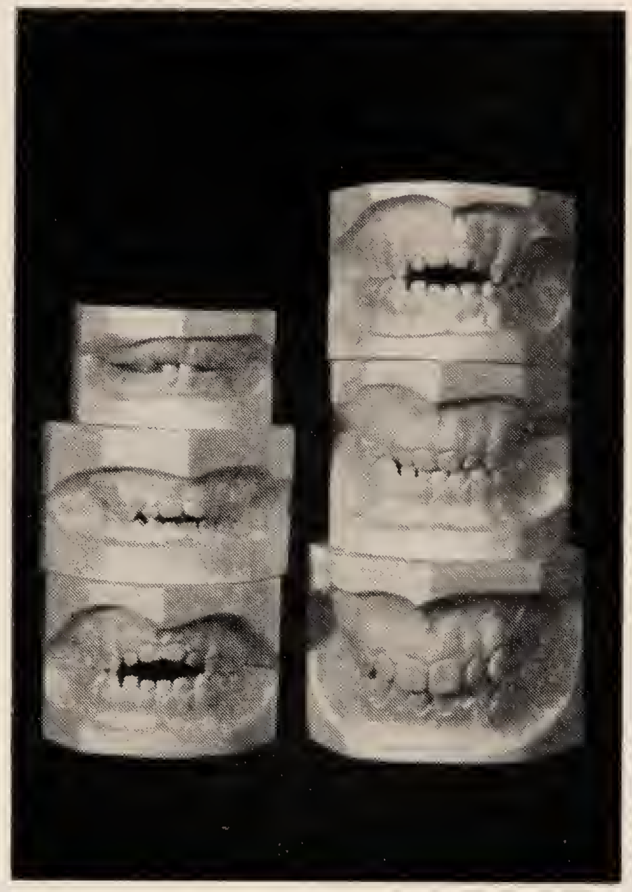


Fig. 8.—The development of an anterior open bite and a mild cross-bite is associated with dummy sucking. Although the open bite closed as soon as the habit ceased, the cross-bite remained until the deciduous teeth were replaced.

Table IV.—Distribution of Cases according to the Classification of Arch Relation after the Age of 6 Years

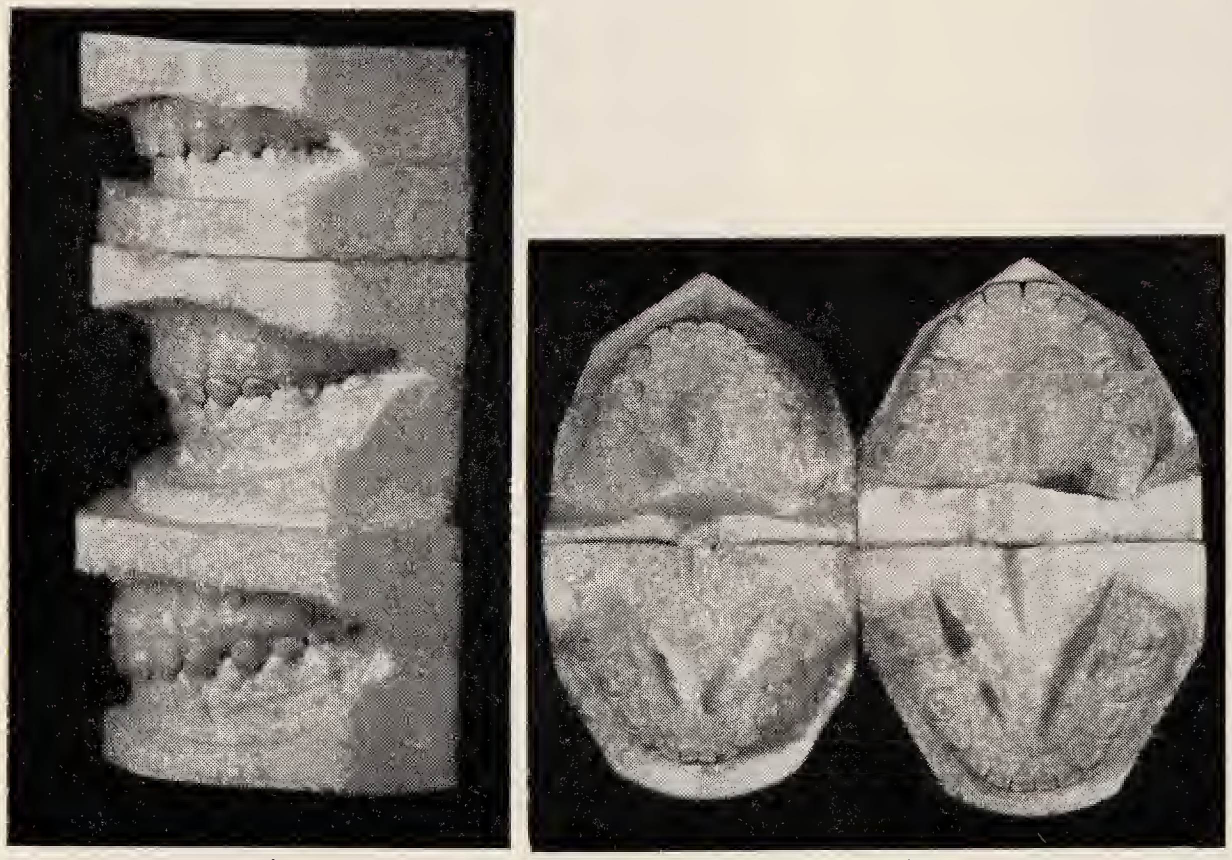
Arch Relation	Controls	Cross-bite Cases	Buccal Occl. Cases
Class I	19	14	1
Class II/1	17	2	3
Class II/2			1
Class III		3	

The age at which the cross-bite appeared was variable, ranging from before 19 months to 5 years (*Table V*). Of 19 cases with a cross-bite of the deciduous teeth, 12 still had cross-bites at the age of 11 years and are likely to retain it in the permanent dentition. These include all but one of the skeletal discrepancies. A further 10 cases were seen who developed a local cross-bite of premolars without there having been any

sign of a cross-bite of the deciduous teeth. These are the result of purely local displacements arising usually from crowding and are not included in the present series.

The development of a unilateral cross-bite is usually accompanied by deviation of the mandible to the affected side on closure. A case is shown where dramatic changes of centre line relation accompany the appearance and disappearance of a cross-bite (*Fig.* 7). The boy sucked a dummy up to the age of $3\frac{1}{2}$ years, and it appears likely that this was the cause of the cross-bite. A further case shows how dummy sucking at this age encourages both a cross-bite and an anterior open bite (*Fig.* 8). Although the open bite improved immediately the habit ceased, the cross-bite remained until the deciduous teeth were replaced. It will be noticed that the upper lateral incisor erupted before the central. This does not indicate the presence of a supernumerary tooth, but is a not uncommon variation of the usual order of eruption.

Although a thumb was sucked in the next case, the habit ceased at about the time of eruption of the deciduous first molars (*Fig.* 9). It is very doubtful if the thumb alone caused the cross-bite which involved the left first and second deciduous molars. It was noticed, however, that the crowns of the upper molars were rather dome-shaped, having only small occlusal surfaces. It is possible that this may have contributed to the cross-bite. Occasionally the cross-bite does not appear until the deciduous dentition is well established. These usually arise where a sucking habit is



A *Fig.* 9 B

Fig. 10

Fig. 9.—A, Although a thumb had been sucked, this had ceased by the time the first deciduous molars erupted. B, The small size of the upper molar occlusal surfaces may have predisposed to a cross-bite.

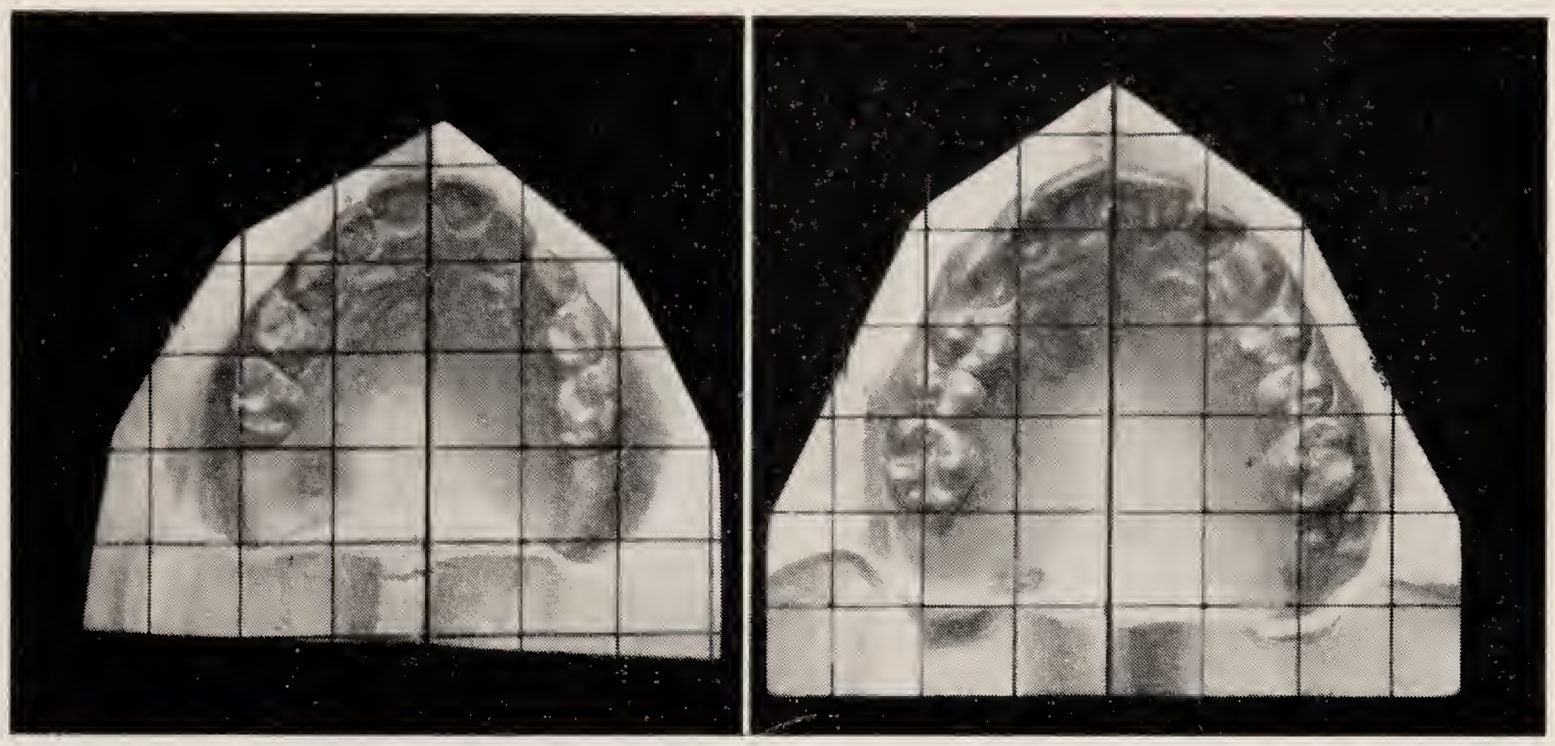
Fig. 10.—The cross-bite in this case did not develop until $4\frac{1}{2}$ years, and, assisted by thumb-sucking, persisted into the permanent dentition.

Table V.—Distribution of Cross-bite Cases according to the Age at which the Cross-bite was First Recognized

Age when Cross-bite First Recognized	Cross-bite ceased	Cross-bite still Present in Permanent Dentition
19 mo.	1	3
31 mo.	3	2
43 mo.	2	5
55 mo.		2
67 mo.	1	

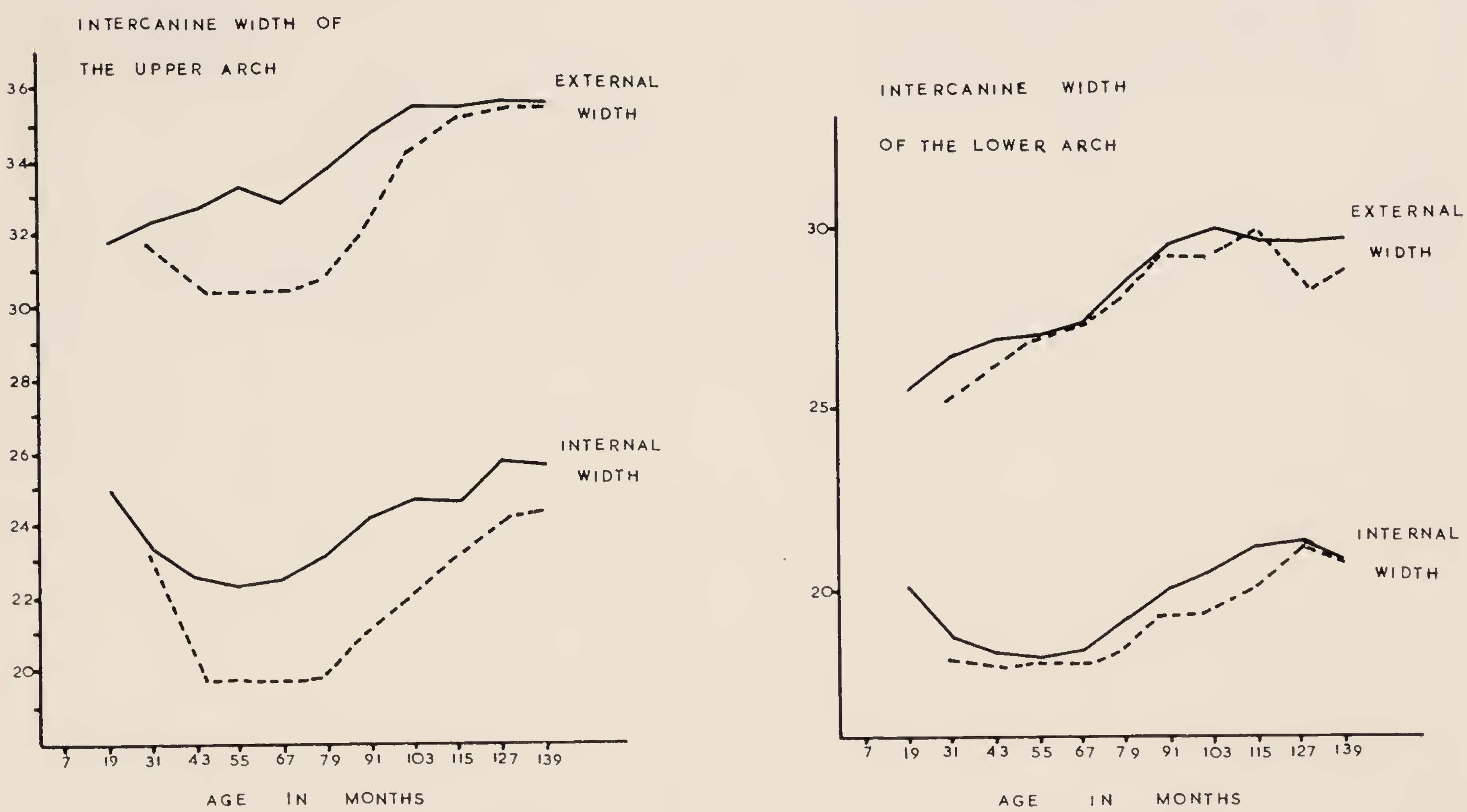
very persistent. Such a case is shown in *Fig*. 10. A thumb was sucked until the age of 11 years, and is almost certainly a major factor in causing the cross-bite. An occlusal view of the upper models at $4\frac{1}{2}$ and $11\frac{1}{2}$ years shows how asymmetry has developed on the side of the cross-bite path of closure, suggests a more stable occlusion had been established.

It is not uncommon to find narrowing of the upper arch causing changes of mandibular position. The graph shown in *Fig*. 12 demonstrates the narrowing of the upper arch between



A B

Fig. 11.—Occlusal view of the last two upper models shown in *Fig*. 10, to show how asymmetry of the upper arch has developed. A, At $4\frac{1}{2}$ years; B, At $11\frac{1}{2}$ years.



A B

Fig. 12.—Graphs plotted at yearly intervals, from mean intercanine widths in millimetres, to compare this case with 36 controls. Initial decrease of both the internal and external upper width of this case indicates unusual contraction of the arch. A, Upper arch; B, Lower arch.

(*Fig*. 11). The cross-bite was not corrected when the deciduous teeth were shed, probably because the sucking habit was still active at this time. The asymmetry, associated with an undeflected

30 and 52 months. This accompanied the frequent sucking of a thumb. At first there was a distal displacement of the mandible and later a cross-bite developed on the right side. When the

first permanent molars erupted there was a change in which the cross-bite moved to the left side (*Fig*. 13). There had been uncertainty about the choice of side for the cross-bite even in the mixed dentition stage. This is confirmed by wear facets on both upper canines.

By and large buccal occlusion cases are found to be at the opposite extreme to the cross-bite cases. They are seen more commonly where the

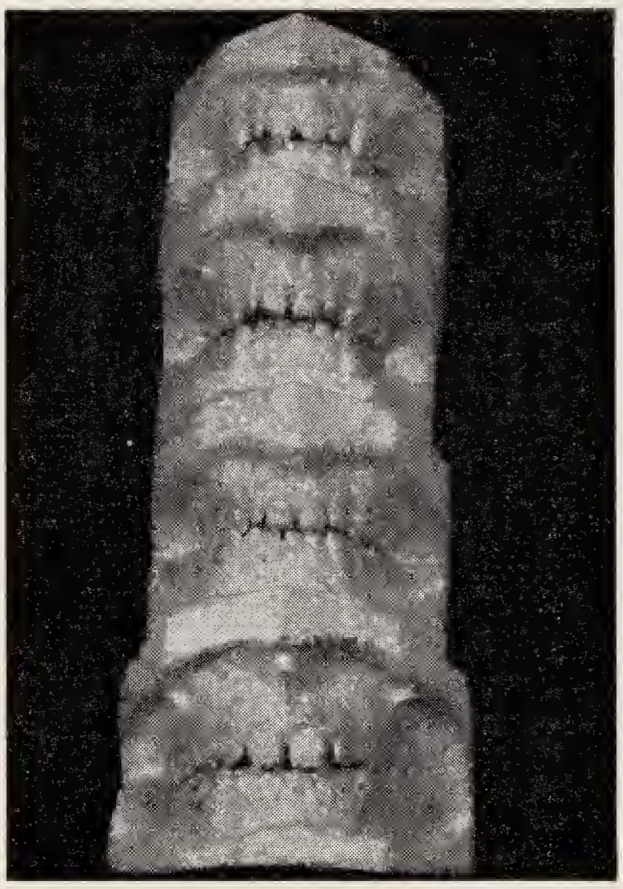


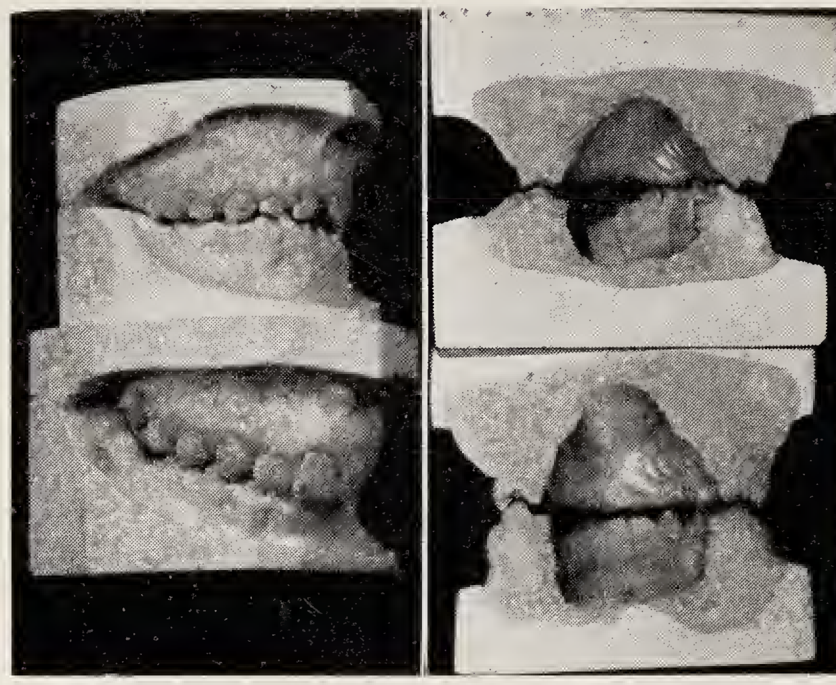
Fig. 13.—Same case as *Fig*. 12. Series of study models to show how intercanine contraction and distal displacement of the mandible precede development of a cross-bite on the right. This was later transferred to the left.

occlusion is postnormal and, like those with cross-bites are capable of spontaneous resolution. Five cases were found where one or more upper deciduous molars were in buccal occlusion. Three of these were corrected spontaneously. Although they all suffered sucking habits, these were all abandoned by the age of 3 years. It is suggested that at least one of these cases may have been fostered by the shape of the molar crowns. These were dome-shaped, having only small occlusal surfaces. This case has already been reported in a previous communication (Leighton, 1963). Although the width of the upper arch was usually in excess of the average, one case showed very marked narrowness of the lower arch with lingual inclination of the lower molars (*Fig*. 14). This did not persist into the permanent dentition. A further case which became worse with age has also been previously reported (Leighton, 1960b).

SUMMARY

Cross-bites of the deciduous dentition may arise as skeletal malrelations of the jaws or may be associated with sucking habits. It is possible that in a few cases morphology of the tooth crowns may play a part in encouraging abnormal relations of molar crowns.

Cross-bites, even skeletal ones are not evident at birth. Quite a high proportion of them become



A B

Fig. 14.—A, Models at 3½ and 11½ years to show spontaneous resolution of a buccal occlusion of the upper right deciduous molars. B, Transverse section of the models in occlusion to show the marked lingual inclination of the lower deciduous molars.

eliminated as the deciduous teeth are shed. The age at which the cross-bite becomes apparent does not indicate its chances of spontaneous correction. The prognosis for those with a lateral path of closure associated with a sucking habit have the best chance for spontaneous resolution. Those associated with skeletal malrelations have a much poorer prognosis. Because of uncertainty in making predictions at present, and because of the frequent occurrence of spontaneous correction, it is not recommended that cross-bites be treated routinely in the deciduous dentition.

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3. LOCAL PATHOLOGICAL CONDITIONS INFLUENCING THE DEVELOPMENT OF THE UPPER LABIAL SEGMENT

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THERE are many local pathological conditions both congenital and acquired which influence the development of the upper labial segment in children. For the sake of brevity, the commoner varieties are listed in *Table I.*

The intention of this communication is to discuss only those conditions frequently referred to our department and which are reasonably within the province of a paedodontist.

The first common problem is that of supernumerary teeth, most frequently found in the anterior maxilla. Sometimes very young children are seen with erupted supernumerary deciduous teeth, usually resembling those seen in the normal series which are easily accommodated in the arch. Radiographic examination in these cases frequently reveals a supernumerary successor, and an appropriate long-term treatment plan for the child may be arranged.

Fused deciduous incisors are not uncommon in the premaxilla and these may be either fused to an adjacent tooth in a normal series or to a supernumerary element. In the former case it is not unusual to find the absence of a permanent successor, while in the latter case the presence of a supernumerary element in the permanent dentition may be present. Sometimes the permanent successor may be represented by an abnormal denticle. This point may be illustrated by the following case in which a male child presented at the age of 3 years 8 months with a fused |AB which were carious, and radiographic examination showed the presence of the developing |13 but the apparent absence of the |2. Delayed eruption of |1 led to a further radiographic examination some four years later which showed a small denticle lying superficial to the developing |1 and apparently impeding its eruption. Subsequent to the surgical removal of the fused |AB and the denticle, the |1 erupted, but follow-up radiographs showed the presence of yet another supernumerary denticle distal to the |1 which seemed likely to prevent the upper left canine from erupting (*Fig.* 1). In this child's family, there is a history of missing and abnormally shaped teeth. His elder sister has a conical-shaped 2| and absence of the |2, and there was also a history of a maternal aunt who had missing upper lateral incisors.

A B C D

Fig. 1.—Periapical radiographs. A, Fused and carious |AB in boy of 3 years 8 months with apparent absence of developing |2. B, Small denticle impeding eruption of |1. C, Subsequent to removal of |AB and denticle. D, Further supernumerary denticle distal to |1, apparently preventing eruption of |3.

Delayed eruption of permanent incisors is another common presenting feature marking the presence of unerupted supernumerary teeth

(*Fig.* 2). These patients are sometimes referred after excessively long periods of observation when radiographic examination shows advanced root formation of the unerupted permanent successors. Another error in treatment planning for these children is a failure to properly assess the occlusion before arranging for the surgical removal of the unerupted supernumerary teeth under general anaesthesia. Subsequently, it may be realized that other teeth should have been extracted for reasons of crowding in the arch. Space maintenance prior to the eruption of the permanent successors after the surgical removal of these supernumeraries may often be required. Excessive delay in the surgical removal of these maxillary supernumerary teeth may result in a prolonged time for the permanent successors to achieve full occlusion. We have estimated that it may take from 1 to 3 years for these permanent successors to achieve full eruption in to the arch. Cases have also been seen where the permanent successor has completely failed to erupt because of an exceedingly long period of wait prior to the surgical removal of the impacting supernumerary tooth. In these cases there has sometimes been an associated dilaceration of the root of the permanent successor.

A

B

Fig. 2.—A, Delayed eruption of $\underline{1|1}$ with retention of $\underline{A|A}$ in boy of 9 years. B, Periapical radiograph of same case showing presence of tuberculate supernumeraries preventing eruption of $\underline{1|1}$.

Table I.—LOCAL ABNORMALITIES INFLUENCING DEVELOPMENT OF UPPER LABIAL SEGMENT

Congenital

1. Partial anodontia
2. Supernumerary teeth
3. Ectopic position of teeth
4. Morphological abnormalities of teeth
5. Fusion or gemination of teeth
6. Odontomes
7. Fissural cysts
8. Abnormal labial fraenum
9. Cleft lip and cleft palate.

Acquired

1. Traumatic injuries of teeth
2. Infection
3. Premature loss of deciduous teeth
4. Pathological resorption of teeth
5. Dental and dentigerous cysts.

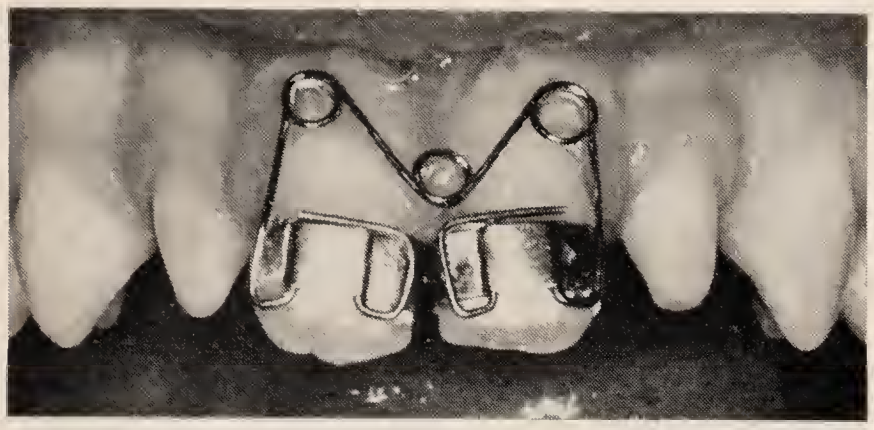
Children are occasionally referred for the treatment of a midline diastema between the upper permanent central incisors which is attributed to an abnormal labial fraenum. However, in a percentage of these cases a mesiodens supernumerary can be seen on radiographic examination which is preventing the approximation of these teeth to the centre line; surgical removal of this tooth resulting in a rapid cure.

The problem of abnormally shaped permanent incisors is occasionally brought to our attention, most common being the conical upper lateral incisor. It is sometimes possible in these cases to restore them with jacket crowns to make them resemble normal lateral incisors (*Fig.* 3). Fusion or gemination of upper incisor teeth is not uncommon. Sometimes the geminated tooth may have erupted but causes a disturbance in the occlusion; stoning of the incisal edge may improve the appearance and the occlusion at the same time. Excessive width of a geminated tooth may prevent normal eruption into the arch and necessitate its extraction.

Fused supernumerary elements on the palatal surfaces of upper central or lateral incisors are

not uncommon and these may be removed by slow and careful grinding. In this way any pulpal prolongations are occluded by a barrier of secondary dentine which follows removal of surface tissue and obviates the necessity for pulp therapy or root filling.

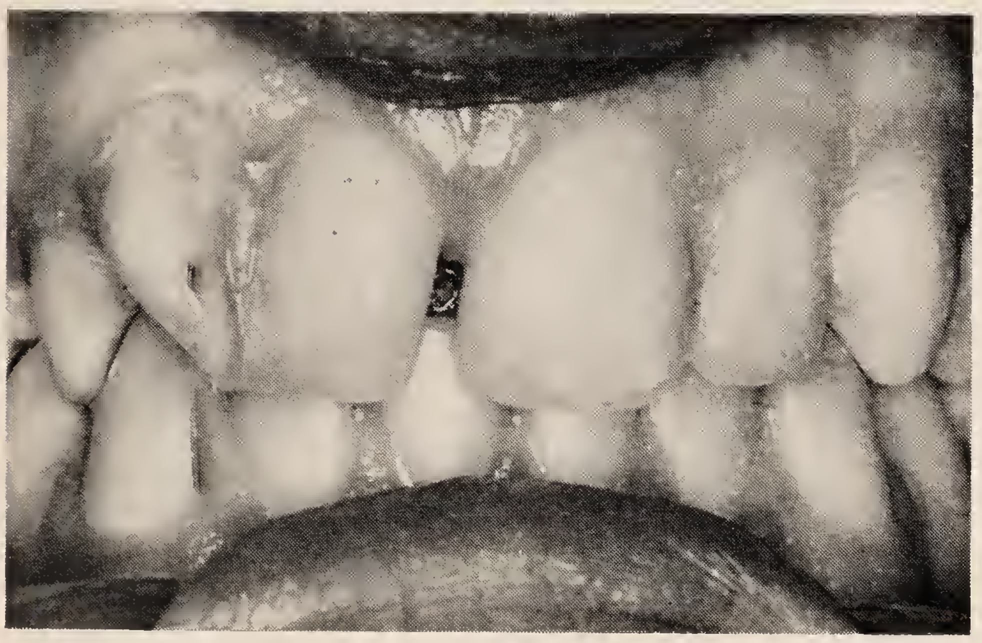
Sometimes, with gross fusions of central or lateral incisors to supernumerary elements a combined surgical and restorative approach may be undertaken to improve the appearance of these teeth and enable a normal occlusion to be obtained.



A

B

Fig. 3.—A, Conical $\underline{2|2}$ in boy of 14 years with fixed appliance approximately $\underline{1|1}$ to midline. B, Acrylic jacket crowns fabricated on gold thimbles used to improve appearance of $\underline{2|2}$.



A

B

C

D

Fig. 4.—A, Fusion of $\underline{1|}$ to distal supernumerary element. B, Periapical radiograph showing fused $\underline{1|}$ with root of supernumerary element labial to $\underline{2|}$. C, Temporary chrome-steel crown on $\underline{1|}$ subsequent to surgical excision of supernumerary element. D, Postoperative periapical radiograph after start of orthodontic treatment.

The following two cases illustrate some of these techniques. The first patient, a boy of 12 years, presented with a right upper central incisor fused to a distal supernumerary element, the root of which was labially placed to the lateral incisor (*Fig.* 4A, B). The distal supernumerary element was severed from the central incisal element with the aid of ultra-speed burs and the distal portion of the crown and root was surgically removed from the bone. Fortunately, no pulpal communication existed between these two elements and a temporary steel crown was cemented to the mesial portion of the fused tooth (*Fig.* 4C). Orthodontic treatment is now being undertaken to correctly aline the upper right lateral incisor and canine and when this has been achieved, a porcelain jacket crown will be prepared for the upper right central incisor (*Fig.* 4D).

The second case was a boy of 15 years with the fusion of the upper left lateral incisor with a distal supernumerary element, fusion being by root only (*Fig.* 5A, B). The distal portion had previously been mistaken for a supernumerary tooth and attempted extraction had fractured the crown from the root. The upper lateral incisor was still vital and the patient extremely keen to save the tooth. Surgical removal of the distal fused element was undertaken successfully. The upper lateral incisor remains vital and the space occupied by the supernumerary element is being closed by orthodontic means (*Fig.* 5C).

Odontomes are not uncommon in the anterior maxilla, the simplest variety being the invaginated odontome. Enamel invaginations occur in both central and lateral incisors although they are far more common in the latter tooth. If these are not recognized soon after eruption of the tooth, rapid infection of the pulp may occur via the enamel invagination which is sometimes incompletely covered by enamel in its depths. Organisms may pass easily through the wide dentinal tubules in the thin portion of tooth substance that separates the invagination from the pulpal tissue. Early pulpal death results and acute abscess formation may be a presenting feature (*Fig.* 6).

Another type of invagination is the so-called *dens in dente* which is a more extreme example of this anomaly. These frequently become acutely infected after eruption into the mouth which necessitates their removal. The most gross example of an enamel invagination is the dilated odontome which, in addition to becoming infected, may also prevent the eruption of adjacent teeth (*Fig.* 7); the surgical removal of these anomalies being necessitated on two accounts. Rather more uncommon varieties of

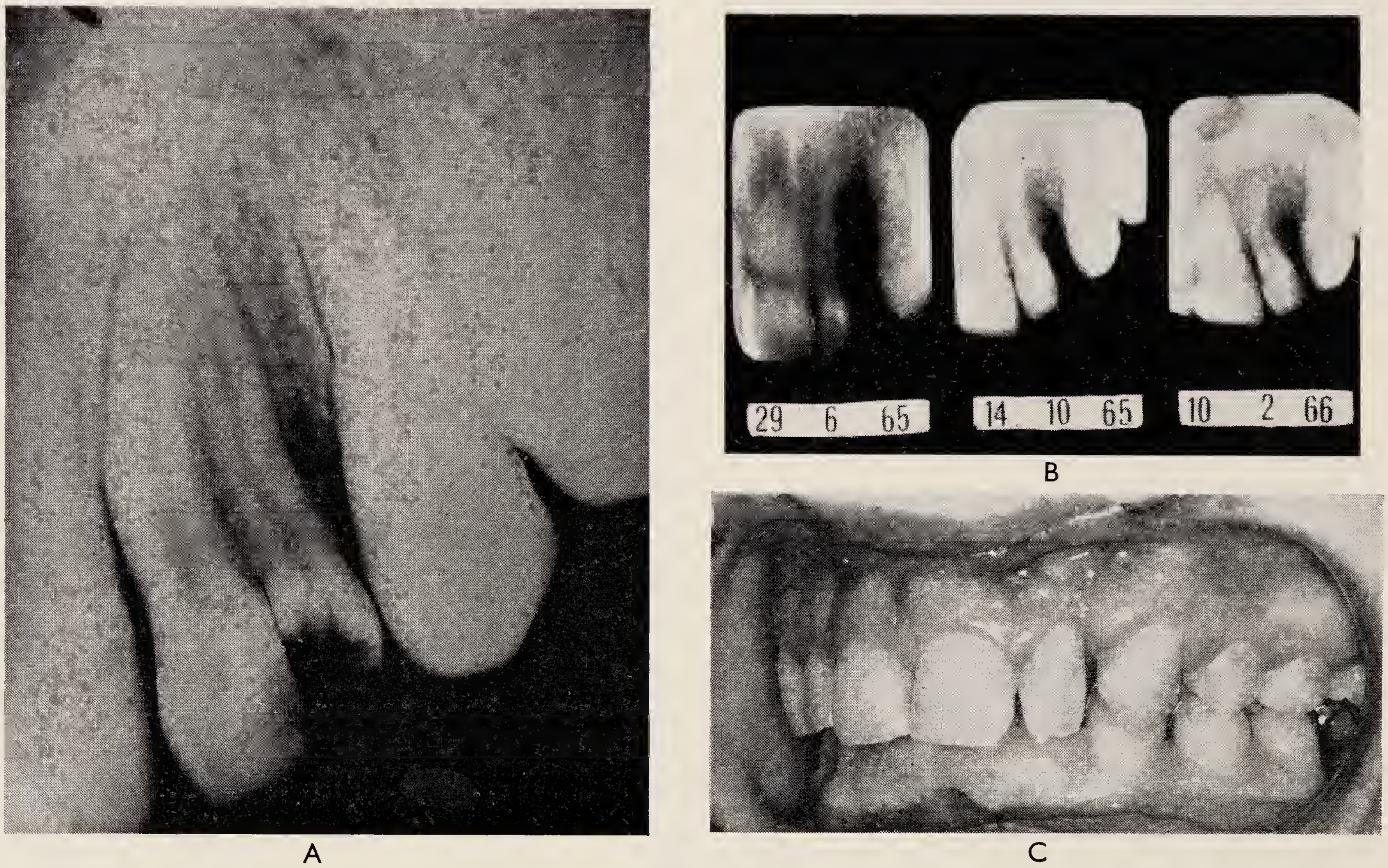


Fig. 5.—A, Periapical radiograph showing |2 fused to distal supernumerary element by apical half of root. B, Further periapical radiographs showing same case after surgical excision of fused element. C, Space distal to |2 in process of orthodontic closure.

odontomes seen in the premaxillary region are the compound and complex composite odontomes. These may, however, prevent or cause a maleruption of the permanent teeth alongside.

The presentation of children with abnormal labial fraenula associated with a marked diastema between the upper central incisors is another condition occasionally seen. Some of these children are referred at a very young age, long before treatment is likely to be necessary for this condition. Children as young as 4 years of age have been referred for fraenectomy when it would be absurd to operate on a condition which may undergo spontaneous resolution. If no other cause can be determined for the midline diastema these cases are kept under observation until the eruption of the upper permanent canines. Continued failure of spontaneous closure may then indicate the necessity for fraenectomy to be undertaken. It is usual in these cases to find a persistent inter-premaxillary suture on radiographic examination and the operation of fraenectomy consists not merely in the excision of the soft tissue fraenum but of

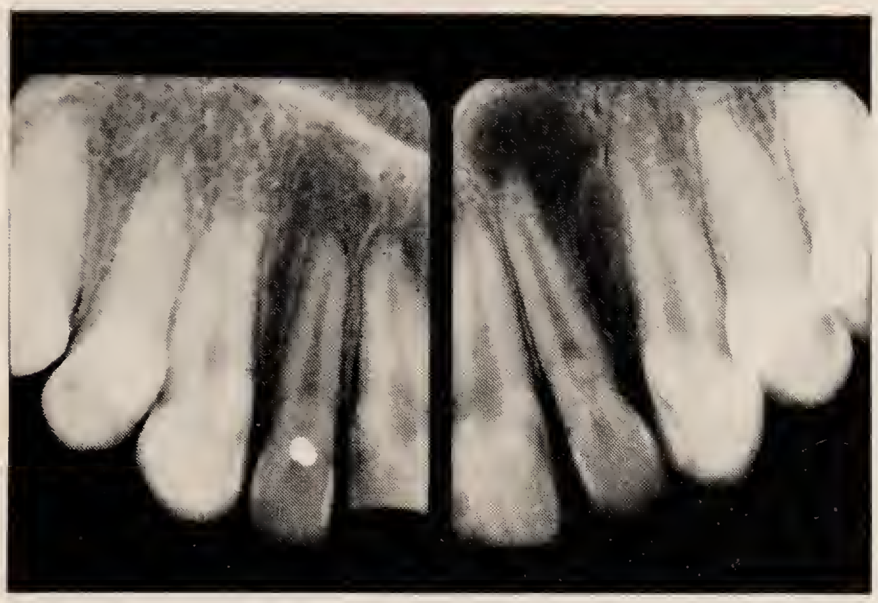
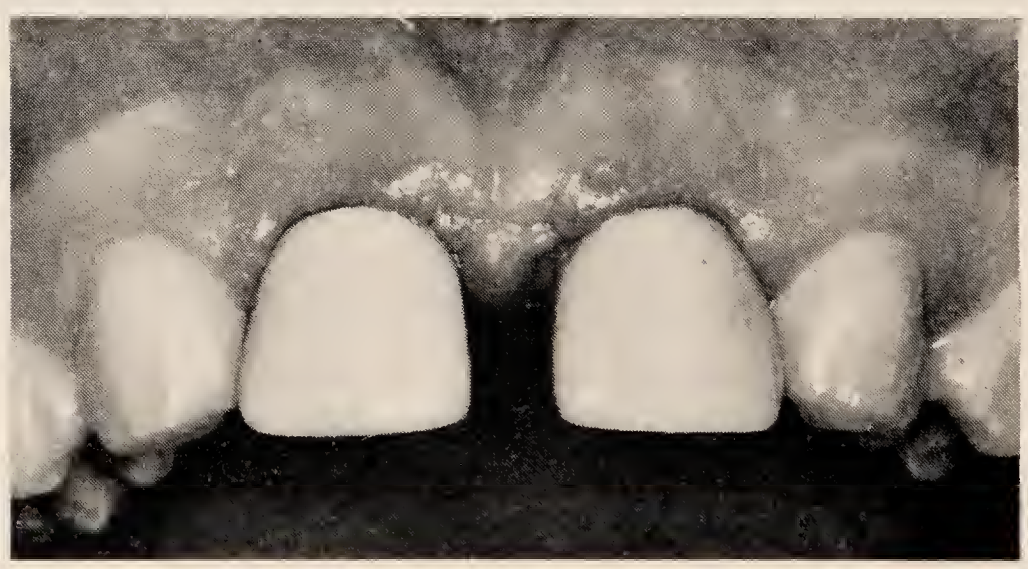


Fig. 6.—Palatal enamel invaginations involving 2|2 in boy of 14 years. |2 has become infected via the invagination and has an area of periapical rarefaction, whereas 2| is vital having been previously restored with silver amalgam.

Fig. 7.—Dilated odontome in girl of 12 years replacing |2 and preventing eruption of |3.

A



B

Fig. 8.—A, Periapical radiographs showing fractured 1|1 in boy of 13 years with gross Angle's Class II, division 1 malocclusion. 1| is incompletely root-filled and has an inadequate post-crown restoration. |1 has a root fracture. B, Same case subsequent to extraction of 1|1, mesiopalatal movement and restoration of 2|2 with porcelain bonded to gold jacket crowns. 3|3 have been stoned on their incisive edges.

Fig. 9.—Periapical radiographs showing progressive root resorption in reimplanted and root-filled |1 which was avulsed in a girl of 10 years of age.

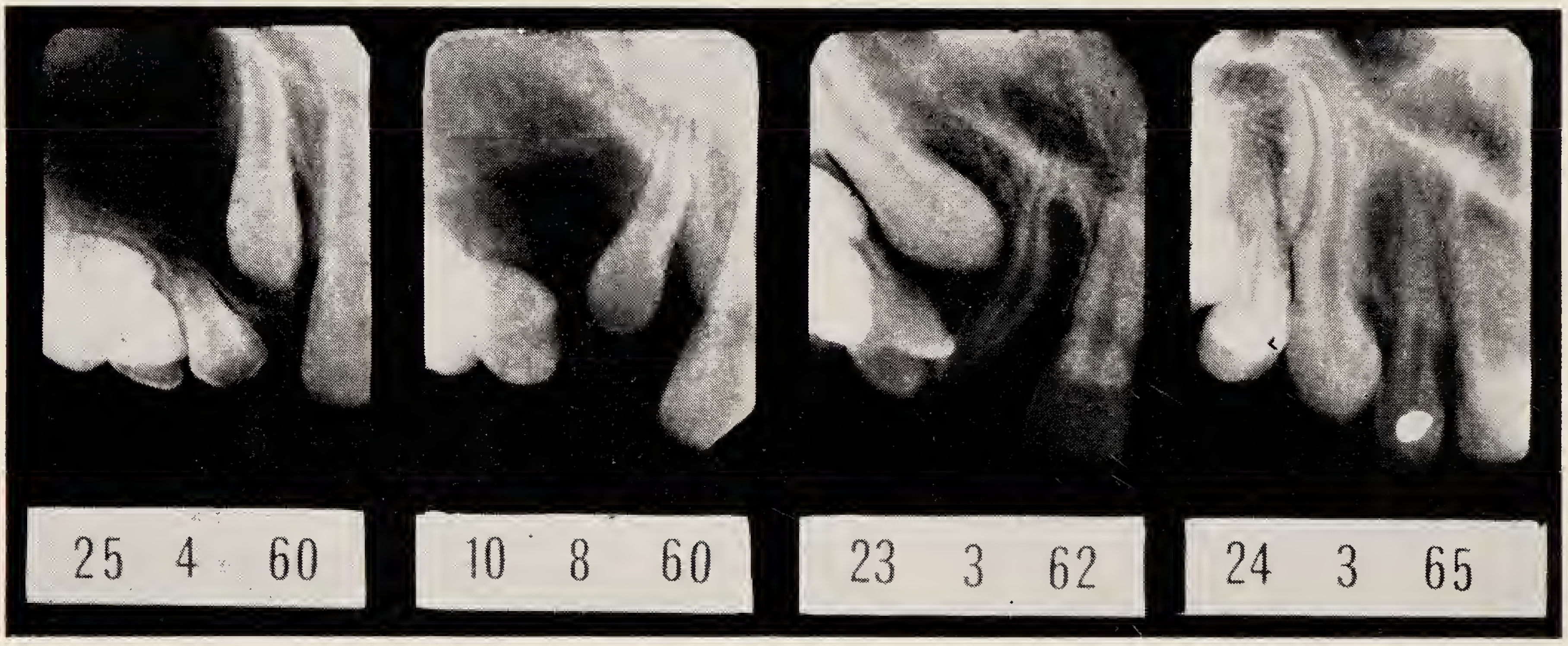


Fig. 10.—Periapical radiographs showing the results of treatment of a large dental cyst on non-vital B| at age of 11 years.

surgical excision of the entire inter-premaxillary suture.

So much for the congenital conditions which may influence the development of the upper labial segment. In addition, there are many acquired conditions which may interfere with the normal development of the dentition in this portion of the arch.

Trauma must surely take pride of place in this respect. Trauma to the deciduous dentition at an early age may lead to dilaceration of the permanent successor and its subsequent failure to erupt. If this proves to be the case, surgical removal of this unit may be required. If this should involve an upper central incisor, it may be possible for space closure to be undertaken and for a jacket crown to be prepared for the upper lateral incisor to simulate the missing tooth. In cases of gross trauma involving the roots and crowns of permanent incisor teeth, it may be necessary in certain circumstances, such as gross Angle's Class II, division 1 malocclusions, to consider removal of these units if their long-term prognosis is poor. Space closure may be undertaken by orthodontic means and if central incisors are involved, coronal restorations may be provided for the lateral incisors to simulate the lost central incisors (*Fig.* 8). Subsequently the canines can be stoned on their incisal edges to make them simulate lateral incisor teeth. Before undertaking these procedures, the lateral incisors must be adequately assessed for crown size and root length to ensure that they will be able to carry the increased size of the crown. With the complete avulsion of a tooth from its socket consideration should be given for the advisability of either the reimplantation of the tooth in its socket or for space closure to be undertaken. This will rest mainly on orthodontic considerations such as the type of malocclusion

that may exist, the presence or absence of crowding and the dental base relationships. If a decision to reimplant is made then this can be undertaken but the child and parent must be warned that this procedure has a limited life. An assessment of cases in the literature would suggest that reimplantation of teeth subsequent to root filling gives an average of not more than 6 years prior to advanced root resorption and subsequent loss of the teeth (*Fig*. 9).

Dental caries is another and all too common condition seen in both deciduous and permanent dentitions. In the former, rampant caries may lead to the gross breakdown in the dentition with infected roots retained in the jaws which may result in the failure, delay, or maleruption of successional teeth. Further, the early extraction of deciduous teeth for rampant caries may also lead to retarded eruption of the permanent successors.

Dental cyst formation associated with either traumatized non-vital deciduous teeth or cariously infected and non-vital deciduous teeth may involve the permanent dentition in the upper incisor region and lead to the failure of eruption of teeth (*Fig*. 10). Adequate treatment for the cyst will subsequently allow for the eruption of these teeth but in certain circumstances full eruption may never occur. This may possibly depend on the degree of alveolar bone destruction that occurs during the time of cyst formation and the subsequent surgical treatment involved.

Resorption of teeth in the upper incisor region is not uncommon. This may be idiopathic in origin or subsequent to local trauma. Idiopathic root resorption is usually of the ‘ plateau ’ type but we have seen several cases in recent months with gross resorption of the upper lateral incisors leading to their early loss. In one case it seemed likely that the unerupted upper right canine was responsible for advanced resorption of the upper lateral and commencing resorption of the upper central incisor roots, whilst on the left side of the maxilla the upper lateral incisor had undergone a similar root resorption but the canine had achieved full eruption (*Fig*. 11). In another case both upper lateral incisors had undergone advanced root resorption and yet both canines had succeeded in erupting into the arch. It appeared that the canines had in some way been responsible for the lateral incisor resorption prior to their eruption. Why this form of root resorption should occur in so few

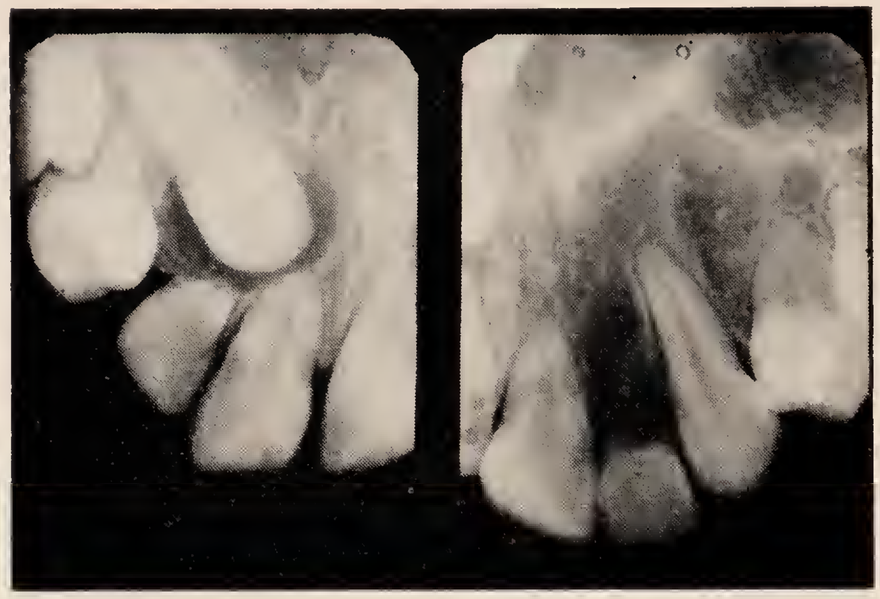


Fig. 11.—Periapical radiographs in girl of 14 years showing root resorption of 21|2. 2|2 were extremely mobile.

cases when one considers the intimate relationship of the canine crown to the developing lateral incisor root is difficult to understand.

Internal resorption of incisor teeth may occasionally be seen, sometimes subsequent to a history of trauma. However, idiopathic resorption may also occur leading to the so-called condition of ‘ pink spot ’ if the crown is involved. If internal resorption can be diagnosed prior to advanced destruction of the tooth, simple pulp extirpation and root filling should be undertaken which will ensure its continued retention.

Conclusion

It has been the object of the paper to draw attention to many of the pathological conditions that may affect the development of the upper labial segment and suggest ways in which some of these may be remedied.

Acknowledgements

I would like to express my gratitude to Professor C. F. Ballard and Mr. M. L. Brenchley for their help with the collection of material for this paper.

IV. PANEL DISCUSSION

Dr. L. M. CLINCH, Mr. B. C. LEIGHTON, and Professor G. B. WINTER

The President: I would like to ask Mr. Leighton whether he found that the unilateral cross-bite was more common on one side than on the other.

Mr. B. C. Leighton: There were six on the left and nine on the right and two bilateral ones. Those on the left all remained on the left. Those on the right all remained on the right except for one, a case where the cross-bite went from one side to the other.

Dr. J. R. E. Mills: I have three questions. Dr. Clinch in her paper referred to Broadbent’s description of the ‘ugly duckling’ stage in the

developing of malocclusion. Could the panel say whether this is an invariable finding during developing occlusion or a usual or an occasional one? Secondly, could the panel say to what extent malocclusion develops after the deciduous dentition has developed, or can you say, when you have a complete deciduous dentition, if this will be a Class II or a Class III occlusion in the permanent dentition. Thirdly, Professor Winter referred to a patient in whom there were supernumerary teeth in both deciduous and permanent dentitions. Has he, and the panel generally, any idea whether this is the usual situation if you have supernumerary teeth in the permanent dentition. Is it usually present in the deciduous dentition also?

Dr. L. M. Clinch: I have no idea statistically how often the ' ugly duckling ' stage occurs. In fact, I do not think it is possible to say because it is a matter of opinion, but it is a very usual thing at this stage of the mixed dentition to find irregularities of the incisors which eventually correct themselves when the teeth have erupted fully.

Leighton: I think the short answer is that you cannot make a definite prediction until the permanent incisors have erupted. There are certain cases where you can be fairly sure—one is with Class III occlusion—but crowding depends entirely on the size of the child and the size of the teeth. Many children appear to be post-normal in the early stages but do not remain so.

Professor G. B. Winter: In the maxilla in those cases with a deciduous supernumerary predecessor, it is not infrequent to find a permanent supernumerary lying somewhere in relation to this, but I think it is probably more common to get permanent supernumeraries where a deciduous supernumerary has not pre-existed. In looking backwards it is difficult to know whether a child has had a previous deciduous supernumerary present in all cases.

Leighton: I would like to ask Professor Winter whether he finds it is more common to find, in the deciduous dentition, supplementary teeth, resembling the normal series, which erupt, whereas in the permanent series it is more common to find supernumerary teeth.

Winter: I agree; I think it is quite correct.

Mr. C. P. Adams: My first question concerns the identification of normal occlusion in the deciduous dentition at 5 years of age. The classical picture according to Friel is that, at this age, the distal surfaces of the second deciduous molars should be in a stepped relation to meet the eruption of the first permanent molars. I wonder if Dr. Clinch could clarify whether this is strictly so in the cases of normal development that she has observed.

Mr. Leighton suggested that certain cases of cross-bite were associated with skeletal discrepancy in the upper and lower arches. I wonder how he identifies this in view of the fact that the inquiry I did myself suggested that the width of the upper arch is not particularly related to the width of the face as a whole.

Professor Winter suggested that when treating an abnormal or large fraenum it was advisable to remove not only the fraenum but also the suture between the premaxillae. I think that radiographs of adult incisor regions show that the suture is still present in the great majority. Also that the width of the suture seems to have no relation in children to the separation of the permanent incisor teeth. Furthermore, the presence of a large fraenum does not mean in every case that the permanent central incisors cannot be brought into contact or are not already in contact in a certain number of cases. Therefore, is this fairly severe operation really required?

Clinch: To the first part of Mr. Adams' question, I would say, ' Yes '. I consider, to get a correct occlusion in the first permanent molars, that there must be a step with the second lower deciduous molar in front of the upper. People say the lower second deciduous molars are larger than the upper and therefore this change can occur at a later stage after the shedding of these teeth, but that is not so. The space that is gained at this time is needed so that the second permanent molars can erupt into their correct occlusion.

Leighton: The skeletal discrepancy was assessed by the inclination of the molars. By this I mean the inclination of the individual's molars' occlusal plane to the occlusal plane of the arch. The assessment was rather crude, a matter of putting a ruler across the upper cusps of the molar.

Winter: With regard to fraenectomy, I agree with what was said almost entirely. The prerequisites for fraenectomy are rare and I think I only do this once or twice a year. I have an impression that one gets a more satisfactory closure of the interspace between the upper permanent centrals if the intermaxillary suture is removed.

Mr. T. Jason Wood: I would like guidance on the matter of treatment of cross-bite. In cases where the midline has not deviated and there is no deviation of the path of closure is it necessary to treat these cross-bites? If you treat a bilateral cross-bite, is it rather likely to relapse?

Leighton: I think the short answer is—no and yes! I would not worry about a unilateral cross-bite nor a bilateral cross-bite where the path of closure was normal. The treatment of cross-bite is undertaken to eliminate an abnormal path of closure. The only treatment I give in the deciduous dentition is to use a stone on the cusps.

Mr. B. B. J. Lovius: Dr. Clinch mentioned that the septum between the developing and

erupting incisors was a cause of spacing. Could she elaborate further?

Clinch: That is simply because the septum is there and the teeth want to erupt in the easiest path and they avoid immediate contact with the septum until they are forced into it. The presence of the septum encourages the teeth to erupt spaced and as the laterals erupt they are forced to move towards the midline, and when the canines erupt, if any more pressure is needed to close the space, that is where it is produced then.

Mr. J. Catcheside: Does Mr. Leighton feel that thumb-sucking and sucking habits are an important aetiological factor in the problem of cross-bites in the deciduous dentition. Does he make strong efforts to discourage this in children of that age?

Leighton: I think there should be a differentiation between an aetiological factor and an initiating factor. Once initiated, I think the damage is already done. I would not interfere with the sucking habit before the age of 8 or 9, and not necessarily then.

Mr. A. J. Walpole Day: One of the things which has come out very strongly today, in the first two papers by Dr. Clinch and Mr. Leighton, is that development follows a normal pattern unless something interferes with it, either environment or some habit, and then we get these cross-bites from sucking habits, etc.

I recently had a patient who sucked her thumb ' to get the juice out ' and another who successfully broke the habit by taking a glass of water to bed. Would Professor Winter say there was any connexion between thumb-sucking and salivation?

Winter: I think there is no doubt that anything that is put into the mouth, a thumb or finger, will stimulate salivation. I do not know whether, if you have a habitual thumb-sucker, the nervous mechanism required for salivation is really dependent on this.

Leighton: I have noticed that children who suck their thumbs seem to salivate less.

Mr. W. A. B. Brown: I am constantly referring to Björk's implant work where, if I look at the arrows of direction of his erupting teeth, they most certainly do not seem to show the teeth are going forwards, upwards, and out, but often backwards and up. Because this seems apparent from the simple diagrams and because his sample is comparatively small, it seems that the generalization we are always making needs to be re-investigated. I wonder what are the opinions of the Panel on this work, because what we teach in the future depends on the validity of this work.

Clinch: I think that, as you say, it needs more investigation. It casts some doubt on what has been taught before, which is valuable, but as evidence it is quite insufficient to support a complete alteration in our line of thought.

Dr. W. Russell Logan: Has Professor Winter had any experience of invagination in teeth other than the central and lateral incisor?

Winter: Yes, I have seen invagination in almost every tooth in the head. There is no doubt that this is commonest in the upper lateral incisors, but I have seen it in lower incisors, upper premolars, in a canine on one occasion, and I have occasionally seen invaginations on the tips of the cusps of molars.

Mr. J. D. McEwen: I would like to ask Dr. Clinch what part attrition plays in the production of the step relationship of the second deciduous molars.

Professor Winter showed supernumeraries in a young child of about 4 years. If the supernumerary is in close relationship to the apex of the permanent incisor at the age of 3 or 4 years does he advise removal at that age?

Clinch: Attrition will not produce a forward movement of the lower arch in relation to the upper. You can have attrition and no forward movement. The cases which are hard to explain are those where you get a forward movement without attrition because one would have thought that the cusp and fossa lock of molars would prevent it, and I can only suppose, in these cases, that it is the morphology of the teeth which allows the change to occur.

Winter: As far as I am concerned, I only operate on supernumeraries when they produce failure or maleruption of teeth in the permanent series. I think it is not uncommon to see inverted supernumeraries in the region of the apices of upper central incisors, and I have the impression that it is wrong to operate on these. If an early attempt is made to remove these, it may result in damage to the permanent successor or its devitalization.

Dr. W. Russell Logan: I want to ask Dr. Clinch if she would agree that lack of attrition may prevent forward movement of the lower arch, as we know very well from the magnificent result which often follows the slicing of unworn deciduous canines? Or is this a heresy to which she does not subscribe?

Clinch: Lack of attrition can prevent a forward movement but attrition does not produce a forward movement. The cases which throw a spanner in the works are those where there does not appear to be attrition and you do get forward movement.

THE VESTIBULAR APPLIANCE

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THESE are functional appliances the use of which has been recently extensively explored particularly on the European continent. The appliance described as a 'Functional Regulator' was devised by Dr. Fraenkel and has been used by him for the last ten years (Fraenkel, 1962, 1963a, b; 1964 a, b, c). These 'Functional Regulators' are skeleton mouth shields which stand clear of all those portions of the dento-alveolar system which are underdeveloped and incorporate a device which dictates a forward position to the mandible (*Fig.* 1). The F.R.1 appliance is used for the treatment of Angle Class II, division 1 types of malocclusion (*Fig.* 2). It consists of two lateral shields which screen the posterior segments of the upper and lower arches from the pressure of the cheeks, two pads which lie over the apices of the lower incisors and canines and shield the alveolar process in the lower incisor region from the pressure of the lower lip, and a lingual bow which exerts pressure on the lower canines and incisors. There is a connecting labial bow in contact with the upper incisors and two clasps acting on the upper canines.

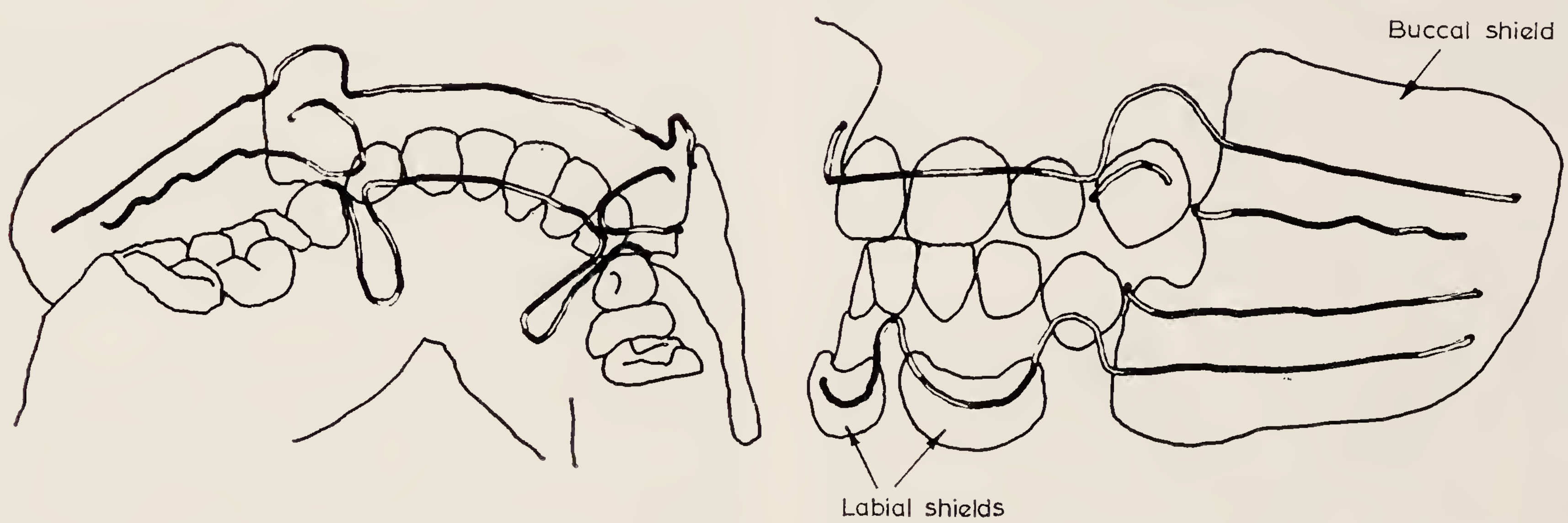

Fig. 1.—The 'Functional Regulator 1' (F.R.1) of Fraenkel seen from A, the lingual and B, the labial aspect.

Fig. 2.—Perverted lip action in Angle Class II, division 1; F.R.1 allows instant lip seal owing to forward mandibular posture.

The appliance combines the screening action of the mouth shield with the protrusive action of the monobloc type of appliance. The appliance can be worn both day and night, except when eating, and this, of course, increases the therapeutic action of the appliance by two-thirds as compared with the usual functional appliance worn at night only.

Casts were demonstrated showing the effect of these appliances under three headings. (1) Stretching of the front of the lower arch with levelling of occlusal plane (*Fig.* 3). (2) Expansion

A Demonstration presented at the Country Meeting held in Eastbourne on 20 May, 1966.

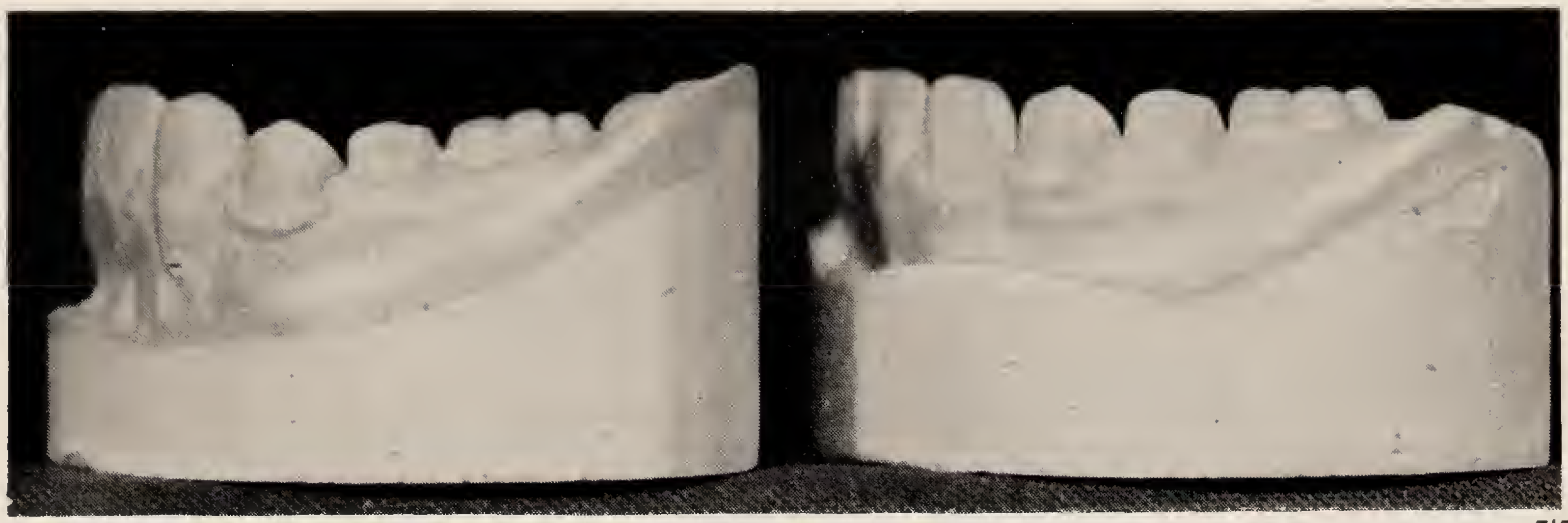

Fig. 3.—Levelling of occlusal plane by the use of F.R.1 after detensioning arch by extraction of $\frac{7|7}{7|7}$.

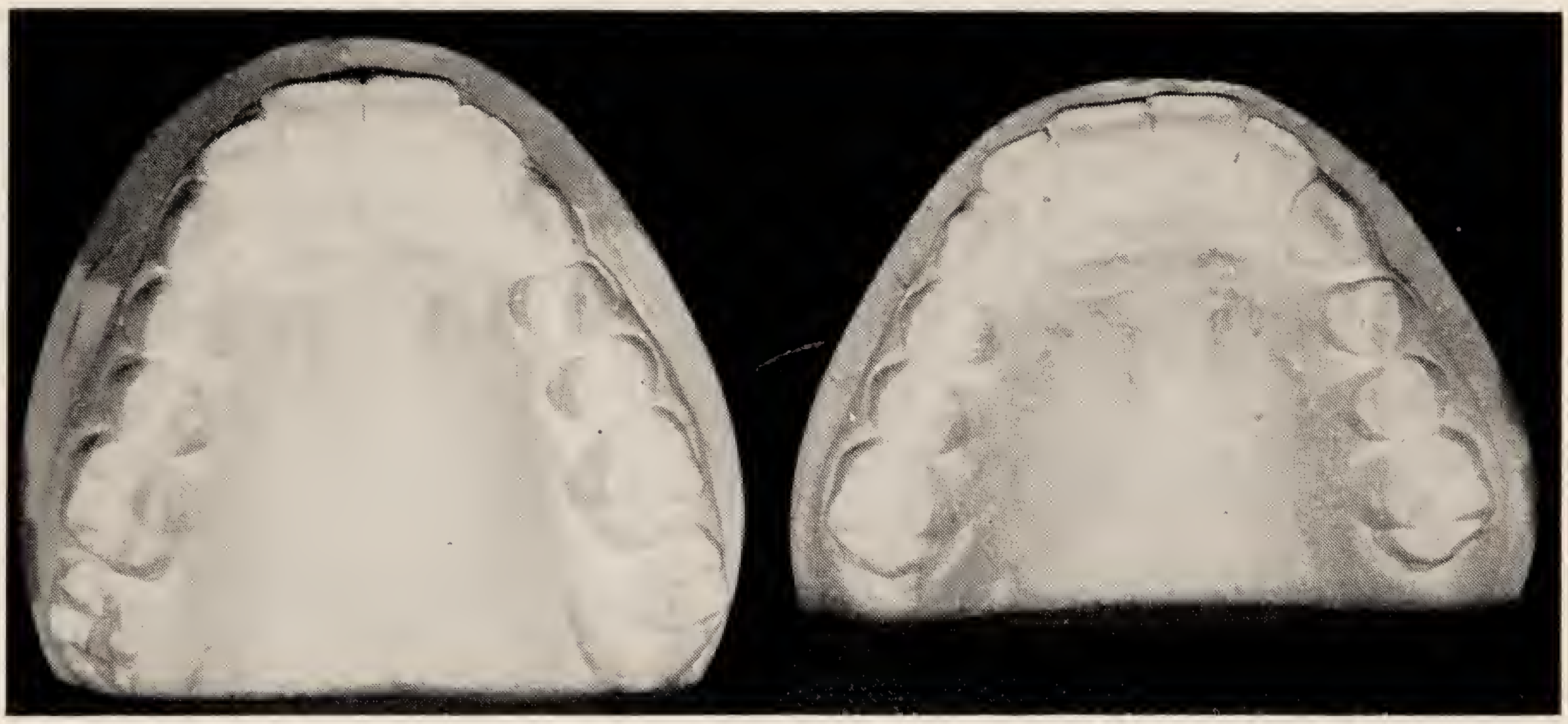

Fig. 4.—Increase in arch width after detensioning by extraction of $\frac{7|7}{7|7}$ and reduction of distocclusion by wearing the F.R.1. for 12 months. Increase of interpremolar width, 2·5 mm. Increase of intermolar width, 2 mm.

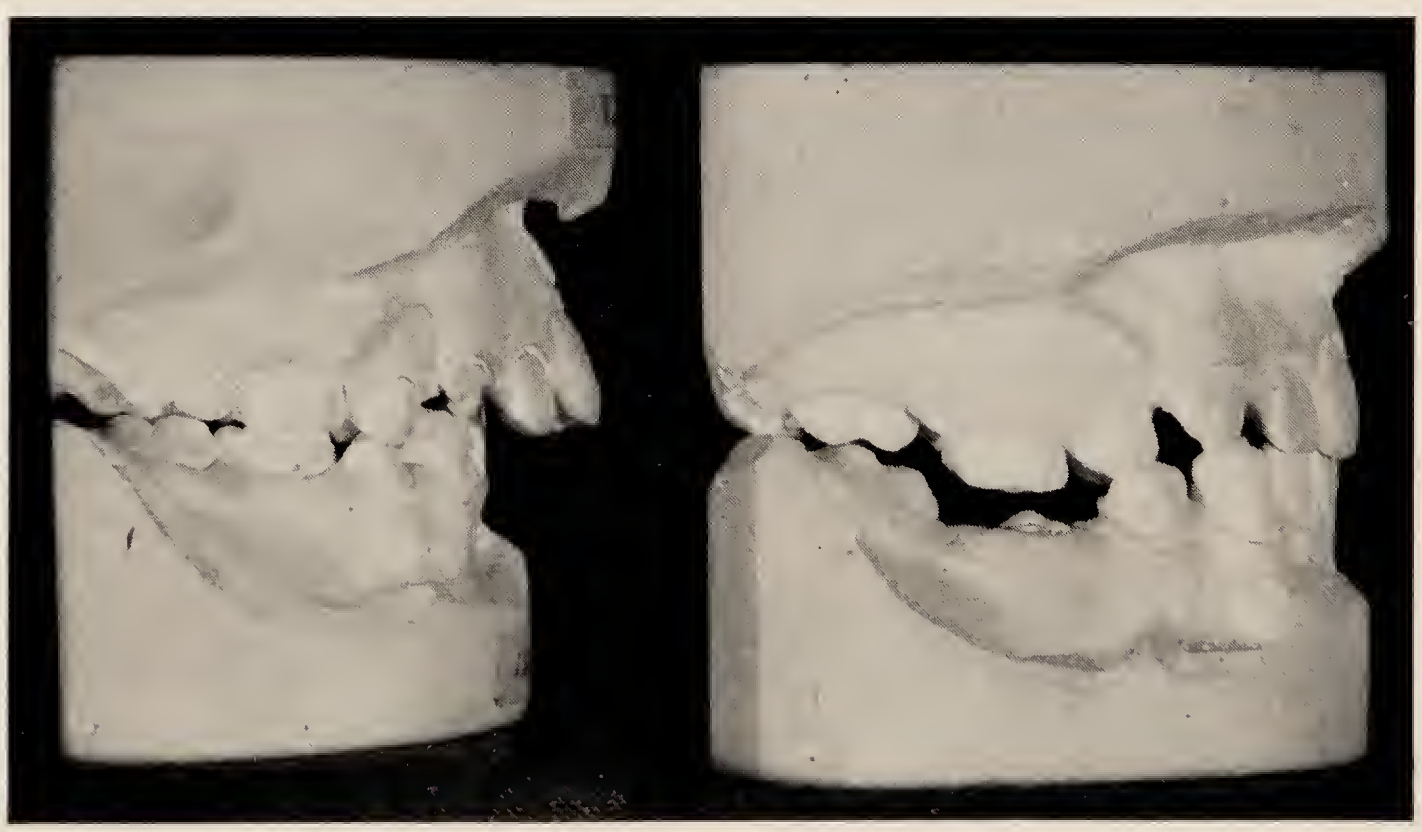

Fig. 5.—Reduction of distocclusion and overjet and decrease in overbite. Extraction of $\frac{6|6}{6|6}$ and 14 months in F.R.1. The mandible cannot be pushed behind the new occlusion; it is not a ' double bite ' or ' bite of convenience '.

of the upper arch in spite of the fact that no portion of the appliance was in contact with the lingual surface of the upper teeth or palate (*Fig.* 4). (3) Reduction of distocclusion (*Fig.* 5).

The appliance is made to a bite registered in the forward position with the upper and lower incisors edge-to-edge, unless the overjet is very excessive in which case a lesser degree of protrusion is registered.

Much depends, as in all orthodontic treatment, on the temperament of the child. Some children find difficulty in wearing the appliance continuously from the beginning. These are best started by wearing the appliance at night only, and only as they gain confidence are they then induced to wear it by day as well. Others will put in the appliance and looking at themselves in the mirror find their overjet gone and the open lips closed, profess their delight at their improved appearance, and wear it continuously from the first visit.

The originator makes use of variations of the appliance for the treatment of Angle Class II, division 2, and Class III cases.

The new 'Functional Regulators' are an interesting development of the functional method and well merit further investigation.

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A RATIONALIZATION OF SOME ORTHODONTIC CLASPING PROBLEMS

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THE use of removable appliances as in British orthodontics today depends upon the Adams crib more than on any other single component. Many European orthodontists still seem to prefer the Schwarz clasp, but the modified arrowhead version (Adams, 1950) is potentially the most convenient and effective retentive device of those commonly used (Oosthuizen and Spruyt, 1965).

However, from observations of appliances in use at different hospitals and practices, a general impression that the device is not being used to its optimum is inescapable. Many cribs are seen which do not retain the appliance well even at the initial fitting, and in use even good initial retention may be lost due to distortion or breakage.

A precise analysis of the construction, clinical use, and effectiveness of the clasps used on routine appliances at the Bristol Dental Hospital confirmed that many cribs used are indifferent, and suggested some of the reasons why.

This paper is an analysis and discussion of some of the problems involved, and an attempt to remove some of the empiricism from the way in which cribs are used. There follows a description of the principles of appliance retention and of the implications in the construction, physical properties, and the clinical applications of orthodontic clasps, and in particular of the Adams or modified arrowhead clasp.

PRINCIPLES OF RETENTION

Retention is the property of an appliance by which it stays in the mouth. It will depend upon a favourable balance between those forces tending to retain it against those tending to displace it.

Displacing forces may be gravity, spring, screw, or elastic pressures, occlusion, mastication, and forces applied inadvertently or purposely by the tongue, lips, or cheeks.

On the positive side some retention will be obtained from a small amount of surface tension and suction, but the first requisite of positive appliance retention will be the effective utilization of undercuts on the teeth.

The availability and the usefulness of these undercuts will be demonstrated and then the

A Demonstration presented at the Country Meeting held in Eastbourne on 20 May, 1966.

problems of making a clasp which will fit, and continue to fit, the undercut will be discussed.

THE AVAILABILITY OF UNDERCUTS

Undercuts were measured on study models of deciduous, mixed, and mature dentitions, fifty uppers and twenty lowers in all, using a Ney cusp point to the given undercut was also measured using dividers.

Using the modal values of the depth at which a given undercut was to be found, *Fig.* 1 was prepared. Certain significant variations were noticed and these have been plotted separately.

Many teeth in the younger patients did not have enough crown length exposed on any of

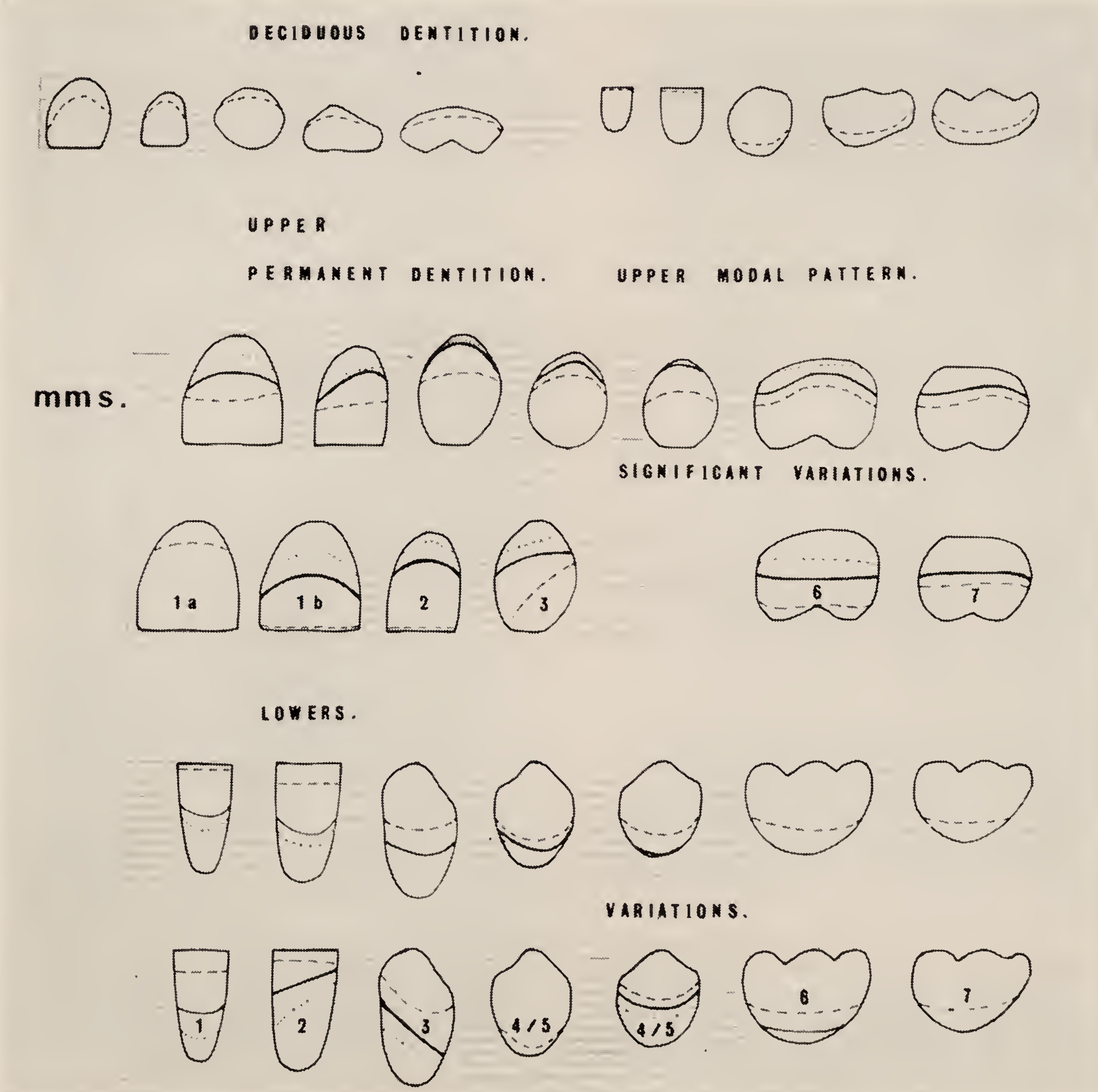

Fig. 1.—Survey lines on the buccal aspects of deciduous and permanent teeth. Maximum convexity shown by broken line (0·010 in. undercut by solid line, 0·020 in. undercut by dotted line). In each case the modal value of the readings obtained is shown. Significant variations in the upper permanent dentition: 1a, retroclined incisors; 1b and 2, proclined incisors; 3, mesially inclined canines; 6 and 7, buccally inclined molars. Significant variations in the lower arch: 1, retroclined incisors; 2, fanned incisors; 3, mesially inclined canines; 4/5, lingually inclined premolars, also buccally inclined premolars; 6 and 7 buccally inclined molars.

surveyor (*Fig.* 1). With the occlusal plane parallel to the base of the instrument, the maximum convexities and the available undercuts on both buccal and lingual aspects of the teeth, and as far round into the embrasures as possible, were plotted using first an analysing rod and then gauges of 0·010 in., 0·020 in., and 0·030 in. as described in the *Ney Surveyor Book* (1949). The depth of the tooth, from the incisal edge or the teeth to expose a measurable undercut of at least 0·010 in. Some do not expose such an undercut even when fully erupted.

Clearly this consideration is pertinent to clasp and appliance design, and in choosing the optimum time for treatment. Chronological age or even dental age are not necessarily any guide to the exposure of undercuts. The best guide would be the use of a surveyor. However,

even without the regular use of such an instrument certain features emerge from this investigation which suggest that the following principles should be applied:—

1. Deciduous teeth are generally poor for retentive purposes.
2. Lower molars have more undercuts lingually than buccally.
3. Upper molars and premolars generally need to be exposed over 4 mm. before any useful undercut becomes available.

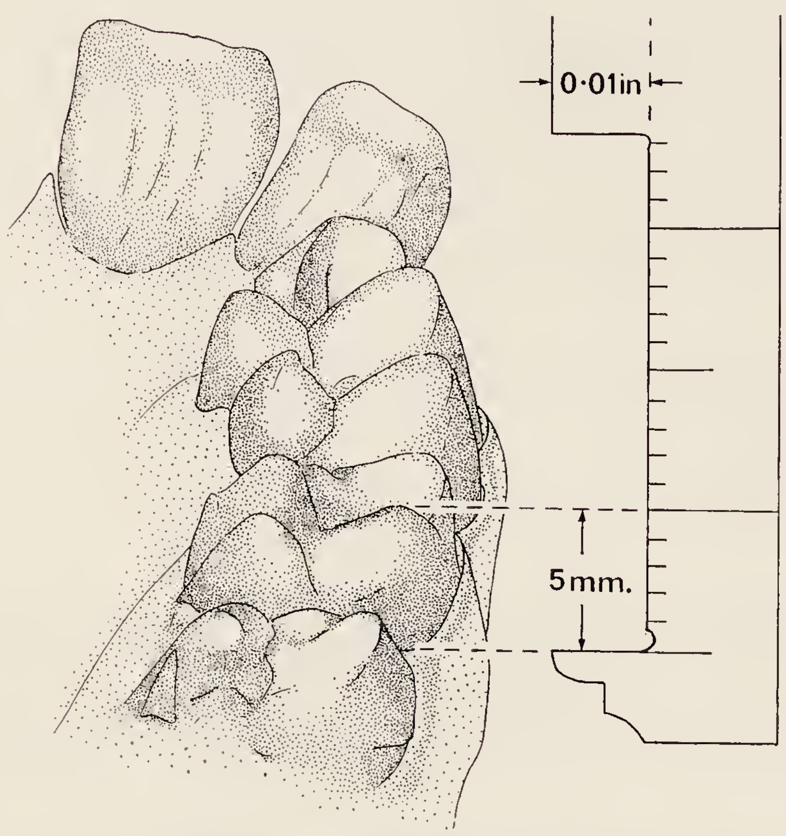

Fig. 2.—Use of undercut gauge. Diagrammatic representation of the stainless rule ground out to depth of 0·01 in. and marked at 5 mm. where the optimum undercut is usually found. The gauge is held against the tooth to assess the depth of crown and the undercut available.

4. Upper incisors soon have available a greater undercut than 0·010 in. An undercut which is further from the incisal edge than about 6 mm. may be too deep for optimum cribbing, particularly if the incisors are proclined.
5. Gingival trimming on the plaster model should not be done so as to expose more than about 5 mm. on any tooth for clasping purposes. In this way gingival irritation is rarely produced. However, it has been suggested that angulation of the arrowheads on partially erupted teeth is indicated (Joffe, 1964).
6. The variations of available undercuts in some types of malocclusions and the optimum depth in all cases could be easily assessed by using a device such as shown, which is a steel ruler cut out so as to leave a 0·01 in. step, and with a mark scribed at 5 mm. (*Fig.* 2).

Upper premolars and molars should generally have arrowheads applied at this depth. On upper incisors the arrowhead should not go much deeper than this.

THE RETENTIVE POTENTIAL OF UNDERCUTS

This was assessed by measuring the force required to disengage appliances bearing cribs utilizing undercuts of measured depth. The study was made on a young adult volunteer, whose well exposed clinical crowns and complete dentition presented a full range of undercuts. A chrome-cobalt replica of his upper arch was also used. A series of appliances, twelve in all, was constructed with two, three, or four Adams cribs in 0·7-mm. hard wire (as supplied by K. C. Smith & Co.), and using 0·010 in., 0·020 in., and no buccal undercuts. Each had a simple baseplate which fitted the palatal aspects of the teeth closely, and this carried two hooks to which forces could be applied. One hook opposite the canines, and the other opposite the first molars. In turn each appliance was fitted to the mouth, or to the model, and measured forces applied to it by means of weights and a spring gauge (*Figs.* 3, 4). On the model this was repeated after fitting and removal some ten times so as judge the effects of any initial distortion.

The results suggested the following principles.

1. Undercuts are Necessary for Retention

Thus only about 1 oz. was necessary to remove the appliances which did not fit into any undercuts. In the mouth, the effects of surface tension were found to be negligible and did not improve the retention. Usually the undercuts utilized are on the buccal surface mesially and distally, but on a mature dentition such as that used undercuts of about 0·010 in. may be present on the lingual. In even younger patients a lingual undercut of over 0·010 in. may be exposed in the lower arch. Such an undercut, if fitted with a baseplate, will give a resistance to removal of about 40 oz., even without cribs.

2. The Use of Undercuts of about 0·010 in. gives an Adequate and Optimum Crib

This undercut gave a resistance to removal of about 50 oz. and deeper undercuts than this did not give a significantly greater resistance.

Cribs using deeper undercuts are more liable to distortion. This distortion was seen at every stage of fitting and use. Thus, even at the initial fitting the 0·020 in. cribs required more adjustment, and they showed more fall off in retentive power as assessed after an initial test of ten fittings and removals.

Distortion is important in that it will reduce retention, and also adversely affect the properties of the wire, which then makes proper function less likely. The amount of distortion occurring is ultimately related to the force required to

disengage the crib. Thus removal of one side of the appliance before the other, and in particular the removal of the back before the front, is seen to increase the distortion, particularly of the incisor cribs. The main reason is that by pulling down one side of an appliance by about 2 cm., which is easily achieved in the mouth, the effective undercut to be disengaged by the contralateral

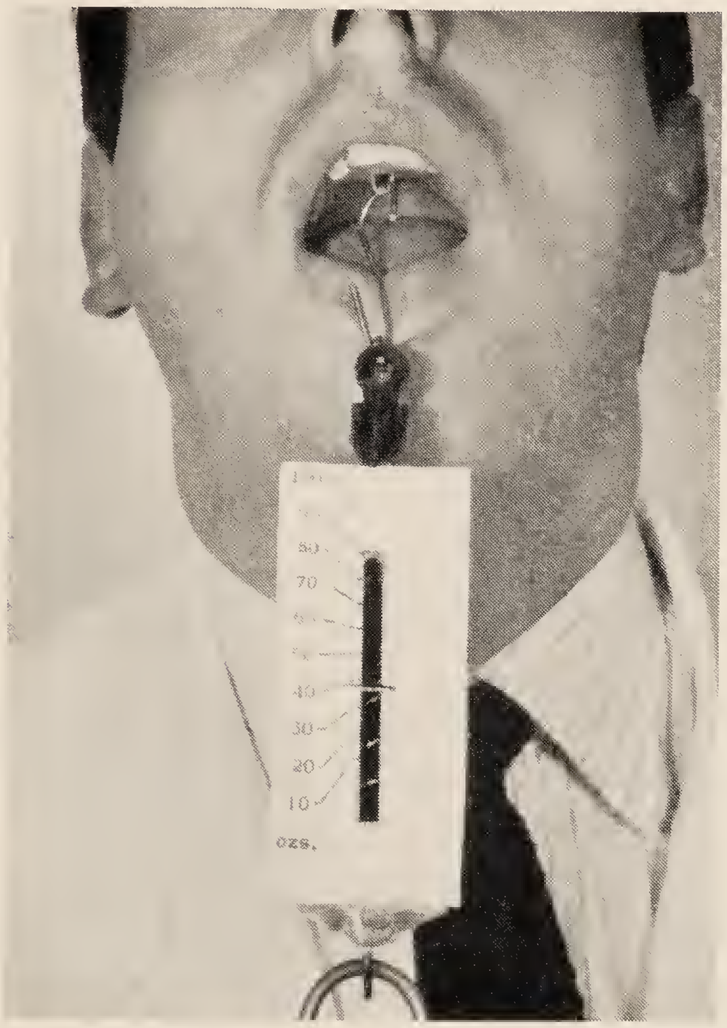

Fig. 3.—Testing the retentive potential of undercuts on the volunteer. A spring balance is attached to the appliance.

cribs is increased to over 0·050 in. which requires considerable force for disengagement. The force required to remove a multi-cribbed appliance may similarly require great force and produce distortion, and so cancel out any original advantage.

3. Cribs Close to the Force tending to Remove an Appliance are most Effective in Resisting that Force

The force in the canine region was best resisted in combination with the premolar or incisor cribs, and the force across the molar region best resisted by the cribs on the first molars. This latter force is the sort of thing that patients sometimes apply by sucking or pushing the tongue under the posterior edge of an appliance. Such a habit is not uncommon among appliance wearers, and the force so applied, measured to be about 20 oz., may be one of the largest forces applied in such a way as to directly oppose retention.

THE REQUIREMENTS OF RETENTIVE CLASPS

Retentive cribs must utilize the available undercuts. Clearly they must:—

1. Fit into the undercut precisely when constructed, and
2. Stay in this undercut in clinical use.

Fig. 4.—Measuring the retentive potential of undercuts on a chrome cobalt model.

The detailed analysis of appliances showed that these conditions are often not fulfilled. By looking at appliances during construction, when delivered on the working model before fitting, and then in use in the mouth, faults were revealed and classified into:—

1. Cribs which are a poor fit on the working model. (Few in this sample.)
2. Cribs which fitted the working model well and yet the mouth less well. (A common finding.)
3. Cribs which became a worse fit during use in the mouth. (Almost universal.)
4. Cribs which actually fractured in use. (Very few.)

All these are considered to be ‘ clasp failures ’, although the clasp itself may not be the actual cause as will be seen. A careful observation of laboratory and clinical techniques was made, and then some of the suspected problems were further investigated under the controlled and simplified conditions provided by using a chrome-cobalt

replica of an upper arch rather than an actual patient.

CAUSES OF CLASP FAILURE

1. Poor Fit on the Working Model

This was observed on a few appliances delivered to the surgery in position on the working model. On the chrome model an experimental series of appliances was made and this fault repeated itself. From the observations the following causes were recognized:—

a. Inaccurate Wire Bending. Some cribs just do not fit. Others appear to do so and yet distort after de-flasking due to being non-passive as bent up.

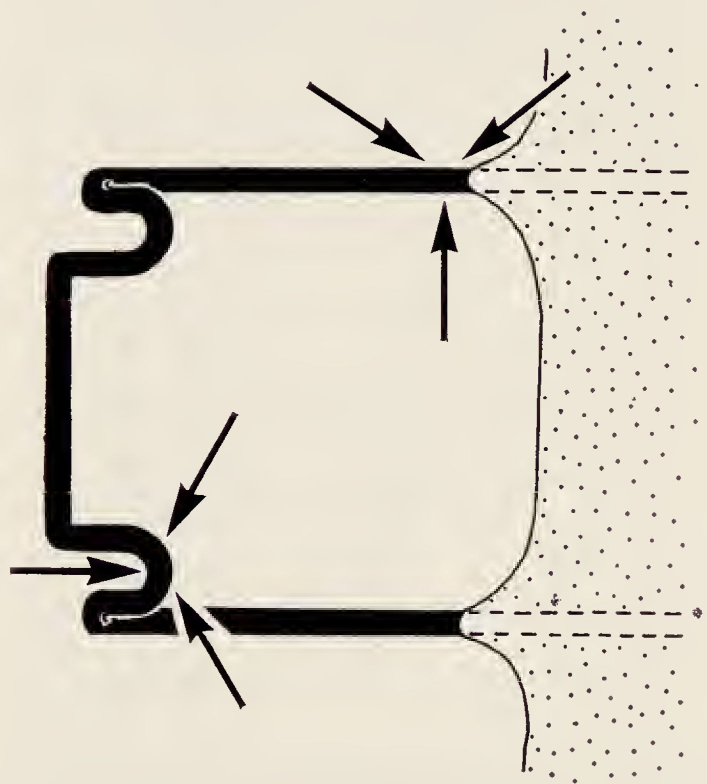

Fig. 5.—The areas of stress concentration in modified arrowhead cribs.

b. Distortion in Flasking, particularly when using acrylic dough which is too hard, or cribs which are inadequately held in position either by hooding in investment, or not held down onto the palate with cold-cure acrylic before packing.

c. Distortion in Deflasking due to chipping away of hard investment from around the cribs or the prising of the appliance off the model. The force required to remove the appliance from deep undercuts is particularly liable to produce distortion.

2. Good Fit on the Model and yet Indifferent in the Mouth

In the clinical series of thirty appliances investigated this was a common finding. It was postulated that this could be due to: (*a*) Movement of teeth since the impression and/or (*b*) Inaccurate working models.

To test this further another series of appliances was made on the chrome-cobalt replica so as to eliminate (*a*). Impressions were taken with alginates, duplicating materials, and composition.

Only the duplicating material gave good and consistent results in terms of well fitting appliances. Alginate impressions can become distorted during the setting, during the removal of the tray from the mouth, or after the removal. For accuracy alginate impressions require a careful technique in well supported trays, followed by prompt and careful model casting.

SUGGESTED TECHNIQUES TO ENSURE AN ACCURATE INITIAL FIT

1. Use first class models from good impressions only.

2. In constructing the cribs bend the wire minimally and accurately.

Follow the technique as laid down by Adams (1950) or Monk (1956), or use preformed cribs such as those supplied by Unitek.

3. Avoid flasking techniques where possible by using cold-curing techniques.

4. Use small (about 0·010 in.) undercuts only.

5. Remove the appliance from the model with care. Cut cribbed teeth off the model first.

DISTORTION OR BREAKAGE OF CRIBS

Those Cribs whose Fit becomes Indifferent in Use

This investigation suggested that this is the most common failure of even the well made modified arrowhead crib. The loss of fit sometimes occurs due to tooth movements such as permitted by intermittent wear, or movement of the anchorage, or intentional movements as in the use of screw plates and extra-oral traction. Most commonly it occurs due to distortion or finally even to breakage of the actual cribs.

This is due to failure of the wire under the conditions imposed upon it, and this failure is induced by stress. Large stresses may cause immediate and apparent fracture or distortion, but even apparently harmless stresses may cause some permanent change in the wire. Repetition of such stresses may produce a steady deterioration in its properties.

Stresses in cribs may be imparted: (1) During construction; (2) During adjustments or in clinical use. The main sites of stress accumulation in Adams cribs are well known to their users. These are the places at which from time to time the cribs fracture, or even before fracture become distorted and so cause a loss of fit. These sites are the point of the arrowhead, and at the junction of the wire and the baseplate (*Fig.* 5).

To demonstrate the distribution of these stresses large ‘ cribs ’ of four times normal size were constructed in glass, embedded into acrylic baseplates, and fitted on to clear acrylic models for viewing under polarized light in conditions of stress.

These demonstrations, although not conclusive in relation to the behaviour of stainless-steel wires in similar situations, did confirm that stress accumulates at sharp bends, at notches in the material, and at abrupt junctions from thin to thick elements.

Stress at the Arrowhead

This is mainly put in during construction. When a loop of wire is bent it can be shown that the stress imparted is proportional to the hardness of the wire, and inversely proportional to the diameter of the loop. For a standard diameter of loop a thinner wire will develop less stress than a thicker wire, but in practice this is usually more than compensated for by the increase in the cold worked state of the thinner wire.

Further stress concentration will occur when any further working of the wire occurs. Stress will further concentrate around any notches imparted to the wire.

Practical Measures to Reduce the Stress at the Arrowhead

1. Accurate first time bending of the wire into the required shape and direction (The technique as described by Monk (1956) is clear and simple). Reject rather than modify inaccurate cribs during construction. In construction of this part of the crib the wire is bent through almost 180 degrees, and this can be shown to be very close to the breakage point of the thinner and harder wires, so that further modification or clinical adjustment may cause fracture.
2. Use medium hard rather than hard wires. The wire used by Unitek for their preformed cribs seems to fulfil this condition, but the marks left on the wires by the construction jigs must remove this advantage to some extent.
3. Avoid tight bends and small arrowheads. Keep the arrowheads reasonably long, in the region of 3 mm. overall, and do not squeeze them up after the initial bending.
4. Use pliers from which the sharp corners have been removed.
5. Do not tighten cribs at the chairside by applying pliers to the arrowheads.

Stress at the Junction with the Baseplate

The stress in this region occurs during clinical use. It produces distortion or even fracture leading in either case to the loss of retention.

Stress at this point is inherent in the design of the modified arrowhead crib. All the forces applied to the crib after processing are ultimately transmitted through this junction. In any such area where a narrow stress-bearing element (the wire) abruptly changes to a wide area (the baseplate) an intense stress accumulation will occur.

An ideal crib would be thick and strong at such a place, and tapered as the stress from the wire is distributed into the baseplate. However, with the Adams crib this is the region which must yield and provide elasticity so as to allow the undercuts to be engaged, and must be therefore reasonably thin. It is also at the farthest point from the bridge or from the arrowheads where most forces are applied, so that it suffers from great force due to leverage.

The causes of stress in the clinical situation may be:—

1. The fitting and removal of appliances—particularly if large forces are required or are applied as in utilizing excessive undercuts, or using many cribs, or in unilateral removal of the appliance.
2. Occlusal forces—either directly on to the tags as they cross the embrasures or even indirectly via biting platforms.
3. Persistent displacement of the appliance by the patient—using tongue, cheeks, or lips.
4. Orthodontic forces applied to the appliance—particularly when large forces are used as in extra-oral traction, or springs which have a downwards displacing component of force, or screw plates.
5. Refitting an appliance forcibly—which has been worn intermittently.
6. Activation of the cribs, or non-passive construction—either purposely as occurs due to model scraping before construction, or inadvertently due to poor wire bending.

The distortions caused by these factors have been observed clinically, and confirmed experimentally by applying stresses to appliances fitted on to the chrome-cobalt replica.

Practical Measures to Reduce the Distortion at the Baseplate-Wire Junction

These will reduce the stress and/or reduce the effects of the stress.

1. *Reduce the Stress by*

a. Accurate construction of appliances on accurate models—thereby reducing residual stress or stress induced by unnecessary adjustments.

b. Use positive but small (0·010 in.) undercuts only.

c. Fit and remove appliances from the mouth so as to minimize the force required.

d. Remove for meals when possible.

e. Advise the patient against habits of appliance movement. Also make such movements difficult—by having good retention, by extending the baseplate as far back as tolerable, and by thinning down the posterior edge to help to stop the tongue getting under it.

f. Tighten cribs when necessary by bending the wire at a point away from this junction.

g. Do not expect one set of cribs to be satisfactory for more than a few months. Use a

new appliance for each set of major tooth movements.

2. *Reduce the Effects of the Stress by*

a. Use wire which will not distort and will not work harden. This will be a compromise so that fabrication will be possible and bulk minimized (thus limiting the thickness to 0·8 mm.) and elasticity and tensile strength ensured (thus a hard rather than a soft wire is used).

Tests were carried out on the different wires available (0·6, 0·7, 0·8 mm. medium hard (tensile strength 100–115 tons p.s.i.) and hard (110–130 tons p.s.i.) from K. C. Smith & Co.) on a machine designed to bend them repeatedly at such a junction as occurs on an appliance (*Fig.* 6). On the machine a rod rotated by hand carries two cams which distort the loops of wire (1 cm. long) twice each revolution. The range of distortions was adjusted by moving the wire loops towards or away from the rod and the rod was rotated at about 70 turns per minute.

The range over which the wires fractured was from about 160 to 5000 distortions. Early fractures occurred with all wires when higher distortions were applied. The medium hard 0·7 and 0·6-mm. wires performed better than the thicker and harder wires, confirming that medium hard wires should be used for crib construction.

b. Use a favourable baseplate-wire junction by keeping the baseplate thin and tapered in this region.

c. Consider a modified design so as to allow more elasticity of the crib away from this junction. This would be facilitated by incorporating more wire into the crib. Alternatively, combine complete rigidity at the junction with flexibility from coils placed close to the arrowheads as Heath (1960) uses with his X plate.

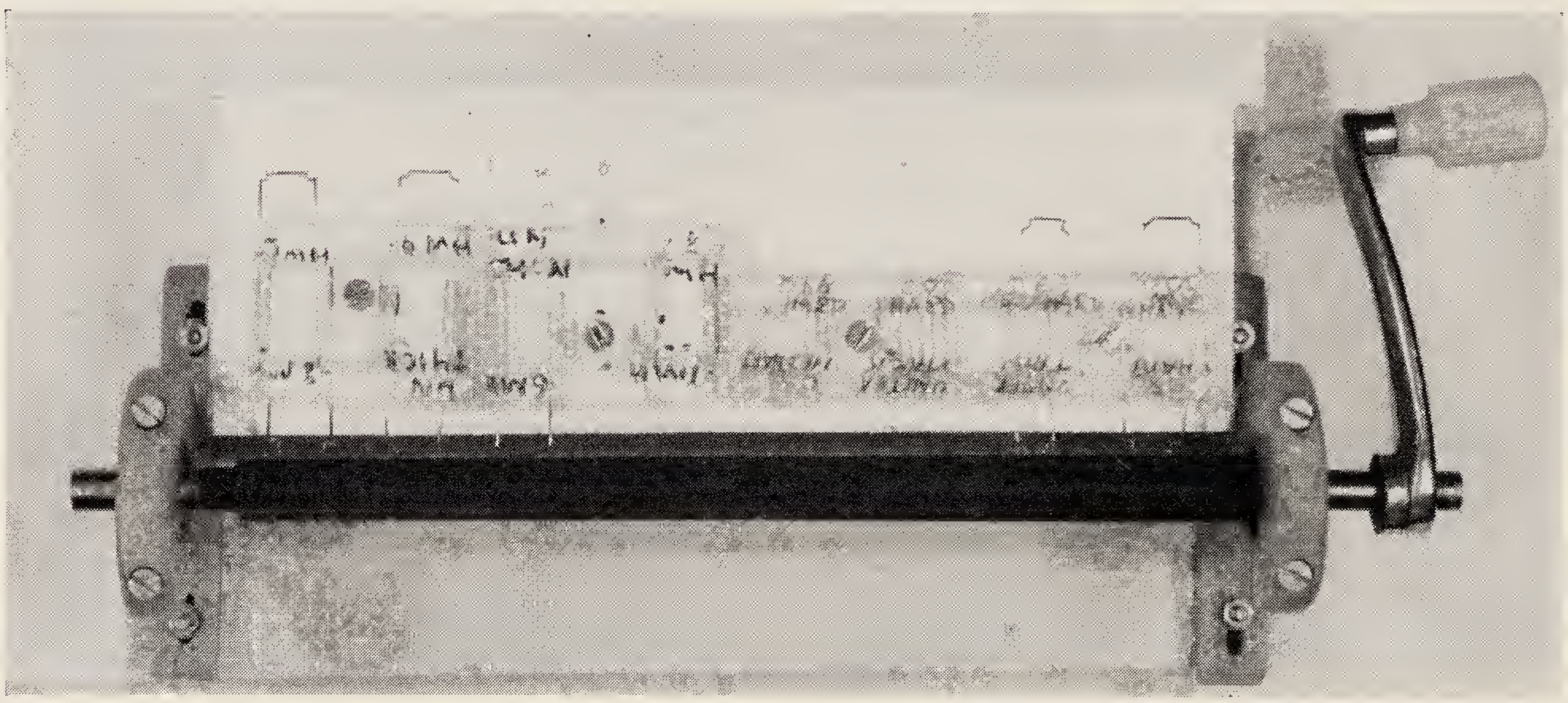

Fig. 6.—Wire-bending machine with cribs in position during testing.

DISCUSSION

The problem of retention of removable appliances is usually concerned with the utilization of small undercuts on the buccal aspect of the teeth. These must be engaged by components which approach from the palatal aspect, and often cross the occlusal plane.

Ideally the design and physical properties of such a component would facilitate this function by having enough flexibility to spring in and out of the undercuts without distortion, and yet have enough tensile strength to prevent distortion at the site of maximum stress. (For a full discussion of the properties of the material in relation to design see British Standard 971/1950.)

This would suggest a clasp which is rigid at the junction with the baseplate and yet springy at the site of the undercut. However, with the cribs at present in use the site of maximum stress is also the place where the elasticity is required to allow undercut engagement. This is clearly a fundamental weakness which it is well to recognize. Tapered wire, modifications as suggested by Heath, or a new design, may help. However, with a more conscious awareness of the problems involved it should be possible to use the present Adams crib, which is the best of those available, to better effect. The crib can and will work well if care is taken along the lines suggested.

Acknowledgements

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THE RAPID ASSESSMENT OF CEPHALOMETRIC RADIOGRAPHS

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This article describes a method of producing a special transparency (Orthogrid) which enables the clinician to rapidly obtain measurements from a cephalometric radiograph.

The technique of obtaining this type of X-ray, described by Hofrath (1931) and Broadbent (1931), is well known. These radiographs are used in growth studies to assess changes in the skull, in diagnosis for the comparison of an individual against accepted ranges, and after treatment to determine the changes that have taken place. Unfortunately, the cost of the equipment and the experience necessary for the interpretation of the radiographs has prevented their universal use. The tracing of the necessary information is also a time-consuming process which does not appeal to the busy clinician. However, those who use cephalometric radiographs have a considerable advantage in the diagnostic field over those who do not. Many clinical impressions can be confirmed and recorded with a greater degree of accuracy, and certain features investigated, which can only be observed by X-ray examination.

The conventional method of tracing a lateral skull radiograph is to fix it to the glass of a viewing box, cover it with a piece of tracing paper or Kodatrace, and mark out the desired points. These can then be measured with the aid of rulers and protractors. The grid about to be described allows the clinician to lay a transparency over the X-ray and read directly the measurements he would previously have obtained from the tracing. It thus eliminates the need for tracing paper, pencils, rulers, and protractors,

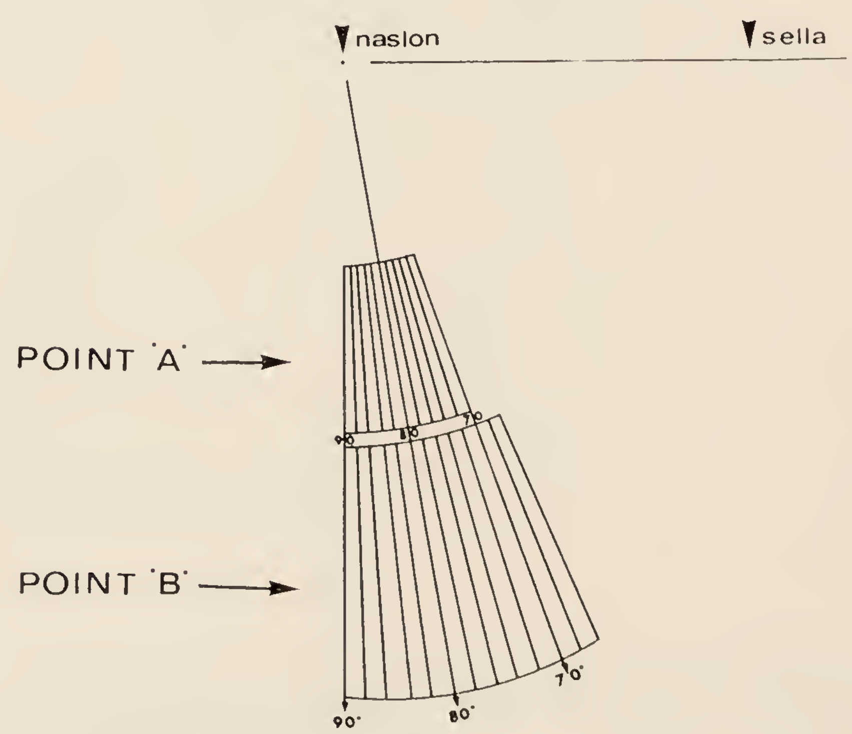

Fig. 1.—Design for measurement of SNA and SNB angles.

A Demonstration presented at the Country Meeting held in Eastbourne on 20 May, 1966.

and greatly reduces the time and effort required to obtain the necessary information.

The information required by various orthodontists differs; however, the transparency we use is designed to give the following information:

4. Axial inclination of the lower incisors to mandibular plane (Margolis, 1943).

5. The angle made by the maxillary plane or Frankfurt plane to the mandibular plane (Tweed, 1946).

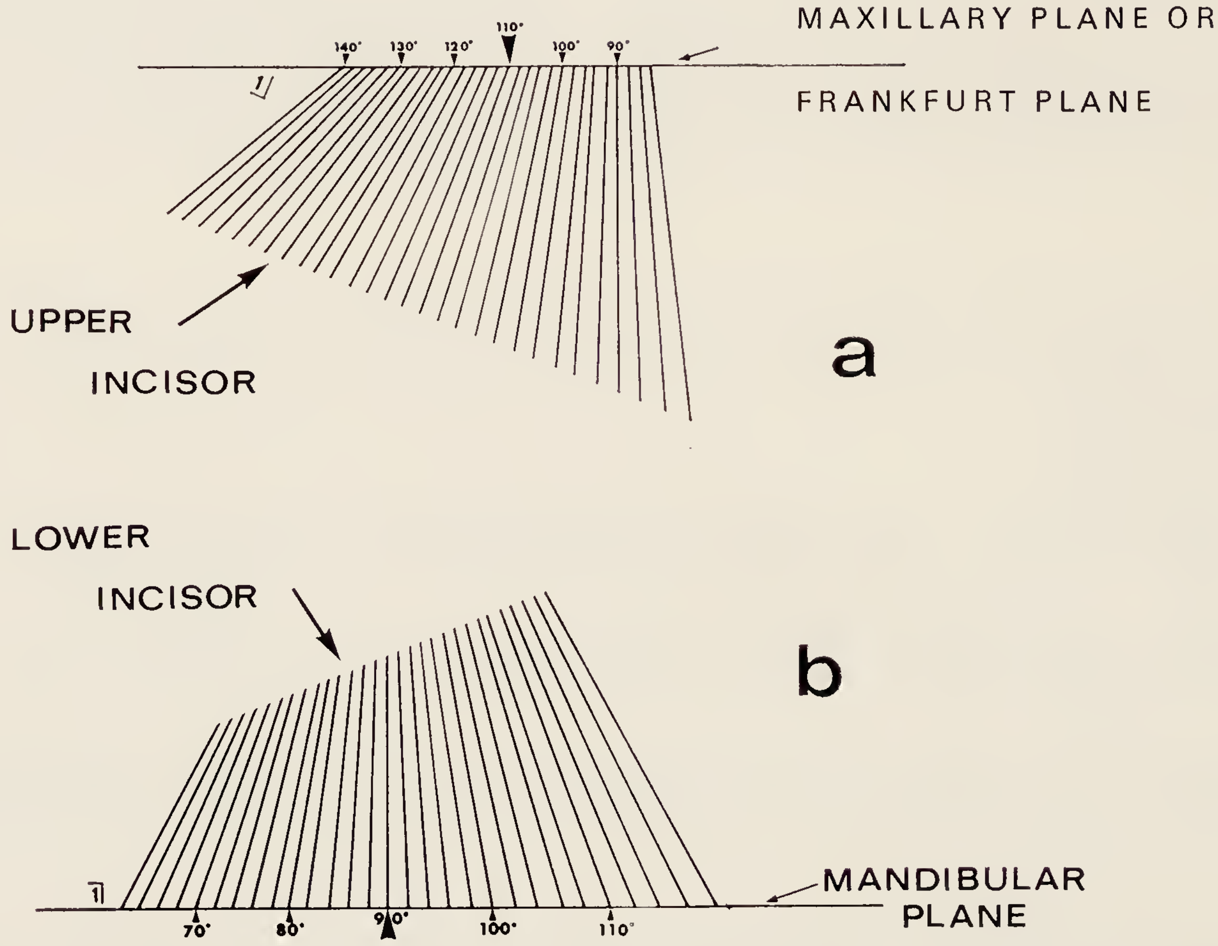

Fig. 2.—a, Design for measurement of the axial inclination of maxillary incisors to the maxillary plane. b, Design for measurement of the axial inclination of mandibular incisors to mandibular plane.

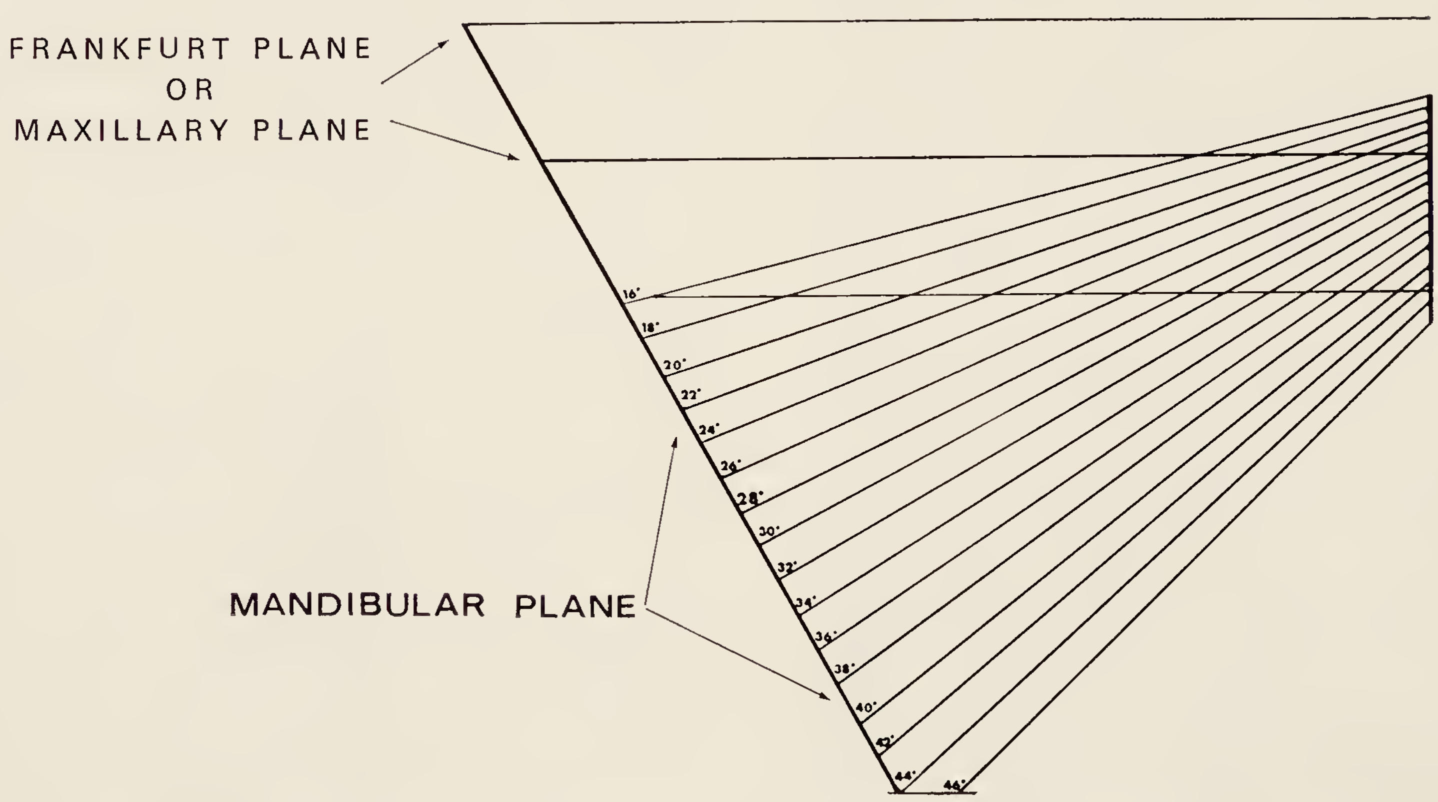

Fig. 3.—Design for measurement of angle between the Frankfurt or maxillary planes and the mandibular plane.

1. Sella-Nasion-point A angle (SNA) (Reidel, 1952).

2. Sella-Nasion-point B angle (SNB) (Reidel, 1952).

3. Axial inclination of the upper incisors to the maxillary plane (Ballard, 1956).

6. The crown root angle of the maxillary central incisor (McEwen and McEwen, 1964).

7. The overjet.

8. The overbite.

Some other measurements can also be made. The first stage in the production of the trans-

parency is to list the maxima and minima of the desired measurements. A grid designed to suit the relevant part of the X-ray is then draughted (*Figs*. 1–4). The separate grids are then composed into a single drawing on Bristol board with the aid of an engineer's pen and compass, and the titles added with a Letraset (*Fig*. 5).

The grid (*Fig*. 1) for the SNA and SNB angles is drawn with 2° spacing in order not to obscure the radiograph, a disturbing feature of an earlier model where 1° spacing was used. In use, the Nasion (N) spot is placed first, then the horizontal line is laid through the Sella (S). The SNA and SNB angles can now be read directly at the ' A ' and ' B ' points.

To measure the axial inclination of the maxillary central incisor (*Fig*. 2a), the horizontal line on the transparency is placed along the maxillary plane on the radiograph. The transparency is then slid along this plane until the axial inclination of the incisor can be read directly. The axial inclination of the mandibular incisor (*Fig*. 2b) is measured in a similar manner.

axis of the tooth upwards or downwards until the labial surface angle can be measured.

The overjet and overbite (*Fig*. 4) can be measured in millimetres from the vertical and horizontal planes, representing the labial surface

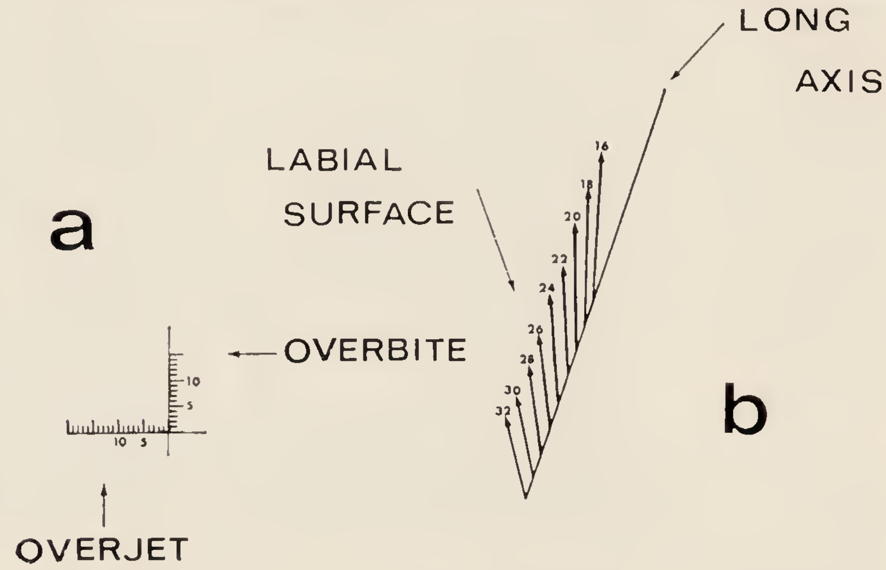

Fig. 4.—Design for measurement of (a) overjet and overbite in millimetres, and (b) the angle between the long axis and the labial surface of the maxillary central incisor.

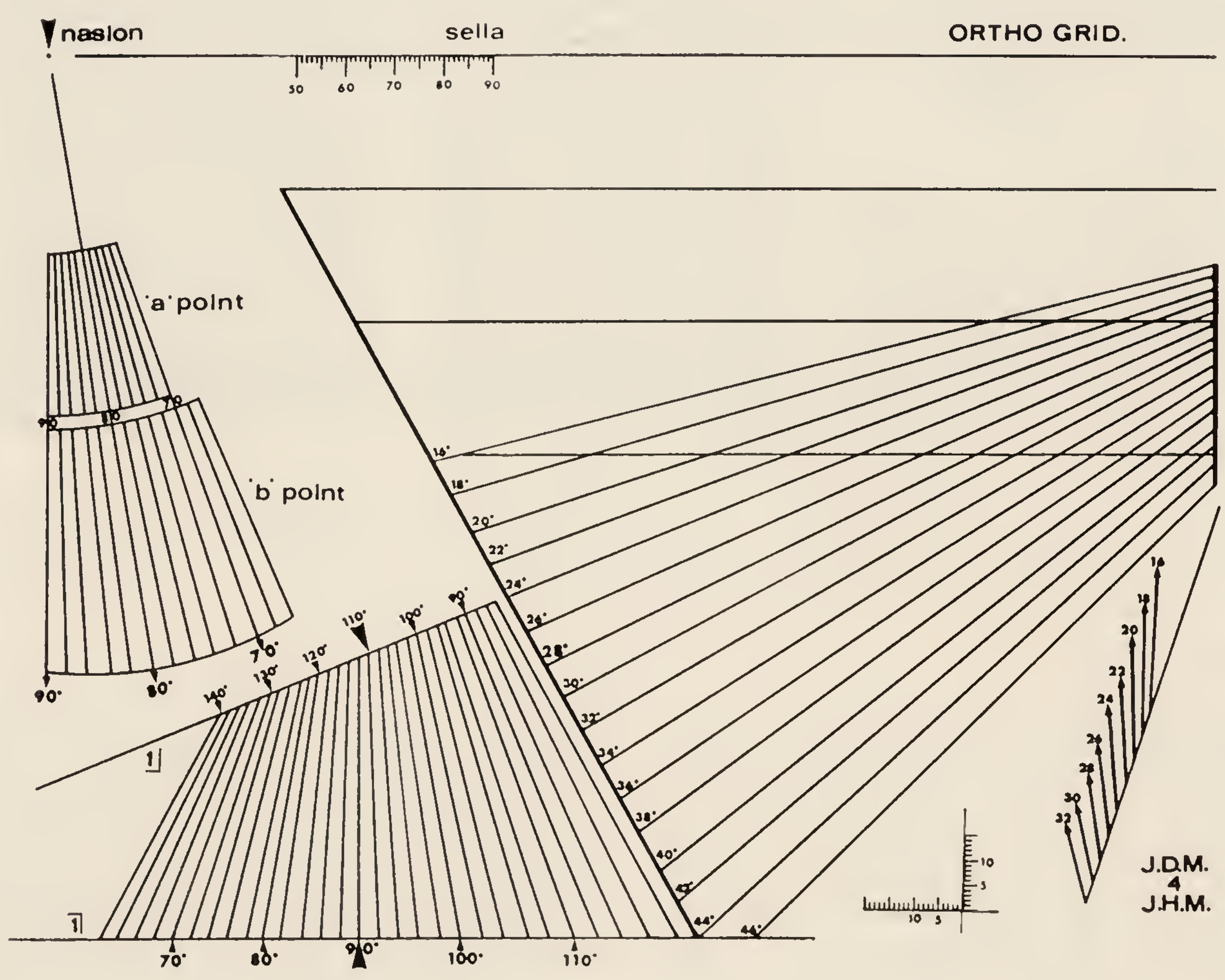

Fig. 5.—Composite diagram which forms final grid.

To measure the angle made by the maxillary or Frankfurt planes to the mandibular plane (*Fig*. 3), the most convenient of four parallel lines is selected and placed on the appropriate upper plane. The transparency is again moved to and fro until the correct mandibular plane angle can be measured.

The angle made by the labial surface of the crown to the long axis of the incisor (*Fig*. 4), is estimated by sliding the line representing the long and incisal edge respectively, of the maxillary and mandibular incisors.

The completed diagram is photographed using full-plate film. This allows a contact print to be made which obviates any distortion that might occur with an enlargement from a smaller film. The contact print is made on Estar Base Kodalith Film, a polyester based film of 0·18-mm. thickness, which has exceptional dimensional stability and resistance to tearing. When processed, it

gives a dense black copy of the original drawing on a clear background. It is flexible and easily moved over a film without fear of scratching or damage.

The transparency can be placed over the film and direct measurements easily read.

Some operators prefer to have the transparency between the cephalometric X-ray and the light source. This allows the film to be moved over the Orthogrid and may allow easier orientation. We have found it best to fix a transparency directly to a sheet of perspex which can be placed on top of a viewing box when needed. Kodalith stripping film is used for this transparency.

This film will adhere to most surfaces, but the highly polished and non-wettable surface of the perspex presents a problem. This has been overcome by using ethylene dichloride first, which dissolves the surface layer of perspex and leaves a fine matt finish. The area to receive the film is then wiped over with a wetting agent (Johnson 326) and Kodalith stripping film cement applied.

The transfer film, previously coated with Kodalith lacquer to strengthen it, is stripped off the cellulose base and slid into position on the X-ray screen. It is gently squeegeed into place, and when the cement is dry the whole area is painted again with Kodalith transparent film lacquer, particular attention being paid to the edges of the film so that a protective layer is built up to prevent accidental catching and tearing when using X-rays.

It is possible to obtain perspex which is coated with photographic emulsion, but the cost is high.

SUMMARY

A method of producing a transparency suitable for the rapid assessment of cephalometric radiographs has been described.

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INDICATIONS FOR EXTRACTION OF THE LOWER SECOND PERMANENT MOLAR

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Removal of the lower second permanent molar in order to relieve impaction of the lower third molar is, in many ways, an attractive line of treatment. But Smith (1957) found that in only 50 per cent of the cases he examined had this approach yielded a satisfactory result. It is therefore important to try to determine which cases are likely to be successful. It is, of course, assumed that the lower first molar is either sound or reliably filled.

The propositions put forward are based on clinical observation of practice and clinic cases over the last 16 years. Patients whose second molars had erupted were X-rayed at intervals of about two years, until it was possible to reach a decision for or against extraction of the lower second molar. The technique used was the lateral oblique method described by Ingram (1950), and it was found that, provided the radiographs were taken by the same operator, they were sufficiently comparable for this purpose. The following set of propositions were found to be generally reliable as a clinical guide.

1. The direction of growth of the lower third molar does not depend on the amount of room available for it, but is determined developmentally. It remains constant until contact is made with the neighbouring tooth, when a ‘ billiard ball action ’ may ensue, by which the third molar may assume a more upright position (*Fig.* 1A).

2. This favourable process may be assisted by physiological growth changes (*Fig.* 1B). Here the distance between the lower second molar

A Demonstration presented at the Country Meeting held in Eastbourne on 20 May, 1966.

and the anterior border of the ascending ramus can be seen to increase, thus providing increased room for the developing third molar. There is The safest cases are those where the upper second molar is controlled by occlusal contact with the lower first molar, as quite often happens (*Fig.* 3A).

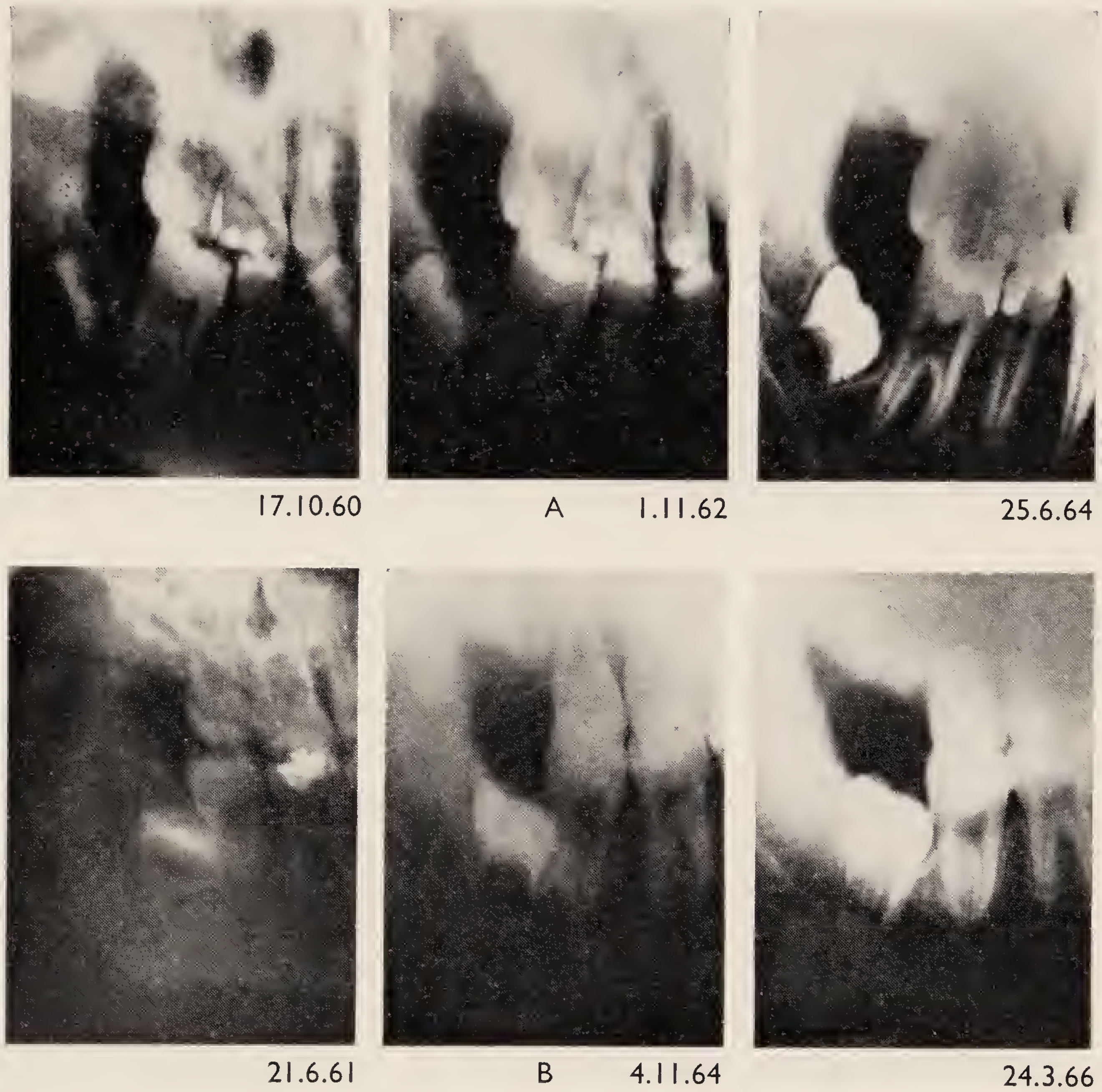

Fig. 1.—Background factors. A, Developmental angle of lower third molar. B, Physiological growth changes.

no crowding of the lower incisors in this case: the change takes place as a result of condylar growth and local remodelling.

3. If, in spite of the above, it is decided that the lower second molar must be extracted, the lower third molar will follow a constant path of eruption as shown in *Fig.* 2, if not interrupted. A small deficiency of space will often be made up by natural growth changes together with the ‘ billiard ball action ’.

4. The upward progress of the lower third molar may, however, be interrupted in two ways. There may be distal settling of the lower first molar, particularly if there is premolar crowding, thus blocking the path of the third molar from in front. There may also be over-eruption of the upper second molar, blocking the path of the lower third molar from above. This can be prevented by extraction of the upper second molar if the upper third molar is well placed; but if this is done too early it is possible for the upper third molar to over-erupt with similar results.

Fig. 2.—Path of eruption of lower third molar following extraction of lower second molar.

5. Case selection therefore depends upon an assessment of the relative probabilities of the favourable and unfavourable changes mentioned

above. In some cases this balance becomes better with the passage of time (*Fig.* 3B). Here the angle of the lower third molar has improved, following growth changes and the ' billiard ball action ', to the point when extraction of the lower second molar can safely be undertaken. The writer's present policy is to prefer a slight excess of estimated space rather than the reverse. An unsuitable case is shown in *Fig.* 3C. Here the angle of the lower third molar remained hopeless throughout, and is now deteriorating even further following contact with the adjacent tooth.

6. This type of case, and others where the issue is doubtful, must be referred for surgical removal of the lower third molar in due cousre. This includes cases where the roots of the third molar are more than half formed, even if the angle is favourable.

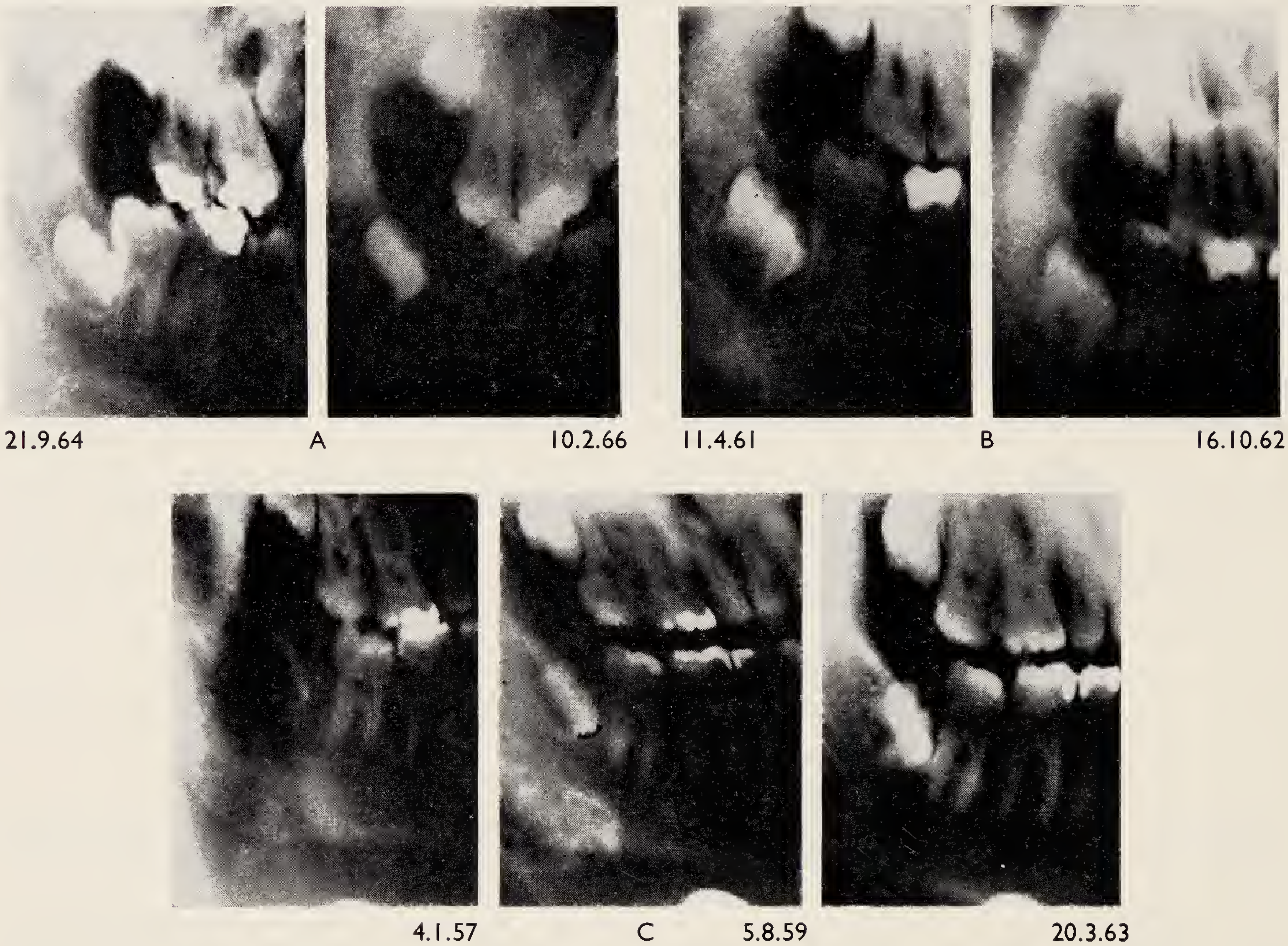

Fig. 3.—Case selection. A, Suitable. B, Becoming suitable. C, Unsuitable.

The end-results of a number of cases were discussed in the light of the above propositions, and it was stressed that while under favourable conditions this line of treatment gives very satisfactory results, any case where there is serious doubt should be deferred.

The writer wishes to thank the Principal School Dental Officers for Birmingham and Coventry for permission to show some cases from the School Orthodontic Clinics; also Mr. Richard Bailey, of Coventry, for the diagram and photographs.

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ADAPTATION TO ALTERED MORPHOLOGY—ILLUSTRATED BY TWO SURGICAL CASES

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The current interest in orofacial musculature is a direct consequence of extensive clinical investigations on the nature of the soft-tissue factor in orthodontics.

Analysis of clinical data accumulated over more than twenty years has enabled Ballard (1955) to show that the basic form and behaviour of the soft tissues are genetically determined. Further, he showed that the adaptive behaviour patterns of the orofacial musculature which are produced as a result of the individual's dento-alveolar and skeletal inheritance, are neither random nor entirely unpredictable. In fact, by postulating that the physiological demands for an oral seal are instinctively satisfied by neuromuscular reflexes and executed in accordance with the principle of least effort, he was able to formulate a biologically satisfactory rationale for the aetiology and treatment of malocclusion (Ballard, 1957).

Prior to the advent of high-speed cineradiography with image intensification, it was not feasible to subject the tongue to the intensive scrutiny which the lips have received. It was therefore necessary to base much of our belief as to the probable nature of the tongue's activity on the limited views from cephalometric radiographs together with the clinically observable movements of the tip of this highly mobile organ. Such evidence as has been available had to be interpreted in correlation with the position of the labial segments which were known to be in a position of linguofacial balance between the tongue and the more intensively studied lips.

The difficulty in monitoring the tongue's activity which has previously hindered investigators inevitably limits our knowledge of the tongue's adaptive response both to physiological and iatrogenic modifications to its rigid dental and skeletal environment.

As the majority of the tongue bulk is situated in the pharynx rather than in the oral cavity, it seems appropriate to consider its pharyngeal relations in conjunction with the more commonly assessed postural and functional attributes of its tip. Although this concept of the pharyngeal status of the tongue is not new, it still remains to be adequately incorporated in orthodontic theory and practice.

In 1960 Ballard and Bond suggested that inherited variations in orofacial morphology influence the mode of production of speech sounds. They proposed that the patterns of behaviour required for articulation of the sounds of speech are modified not merely to produce acoustically acceptable sounds, but also to conform with the individual's inherited morphological characteristics. This not only serves to explain the concurrence of certain speech defects with specific malocclusions, but is also the starting point of this investigation into the relationship of the soft tissues to their hard environment.

Although the investigation, of which the two cases to be described are a part, is principally directed to adaptive movements used in speech, some general conclusions on the nature of soft-tissue behaviour may possibly be derived.

At the commencement of this project some three years ago, a sample of normal subjects was studied, and some of the early observations on the relationship of morphological variation to functional patterns in speech have already been reported (Vig, 1965). The important findings were:—

1. From cineradiographic and cephalometric analyses it was seen that an extensive variety of articulatory patterns may be associated with the production of normal speech.
2. Although variation between speakers is very great, each individual speaker has a basic pattern of movements which is characteristic of all his utterances.
3. It furthermore seemed from the normal subjects that the pattern of movements in articulating speech is not primarily dependent on the relationship of the labial segments. The speech patterns seem more closely allied to the underlying skeletal morphology than to variations in incisor relationship.

Presented at the meeting held on 14 March, 1966.

Putting this in a clinical context, for example, we can have a subject with all the characteristic features of say a typical Class II, division 2 except for a deep incisor overbite. He, presumably, would be classified as a Class I clinical case. On analysis of the cineradiographic films of his speech movements, the pattern of activity is similar in type to the typical Class II, division 2 members of the sample. The movements of the mandible, tongue, and lips were seen, therefore, not as attempts to eliminate increased overjets or overbites, but rather as a more general adaptation of the tongue and the other mobile organs to their rigid confinement within the intermaxillary space. It was therefore suggested that a combination of the size and shape of the intermaxillary space, and probably its relation to the pharyngeal structures, is the most consistent morphological covariant of the variations in articulatory behaviour.

A

B

Fig. 1.—*Case.* 1. Full face and profile photographs, A, before and, B, after surgery. Note the reduction in the lower facial height.

The general trend observed suggests that with a high and long intermaxillary space, movements of articulatory organs are minimal, whilst a short and shallow space usually seemed to be associated with maximal activity of all the structures. The tentative conclusion based on these observations is that articulatory movements are fundamentally determined by three main factors.

Firstly, the acoustic target of the particular speech sound which is to be achieved by shaping the vocal tract to produce the necessary resonant frequencies.

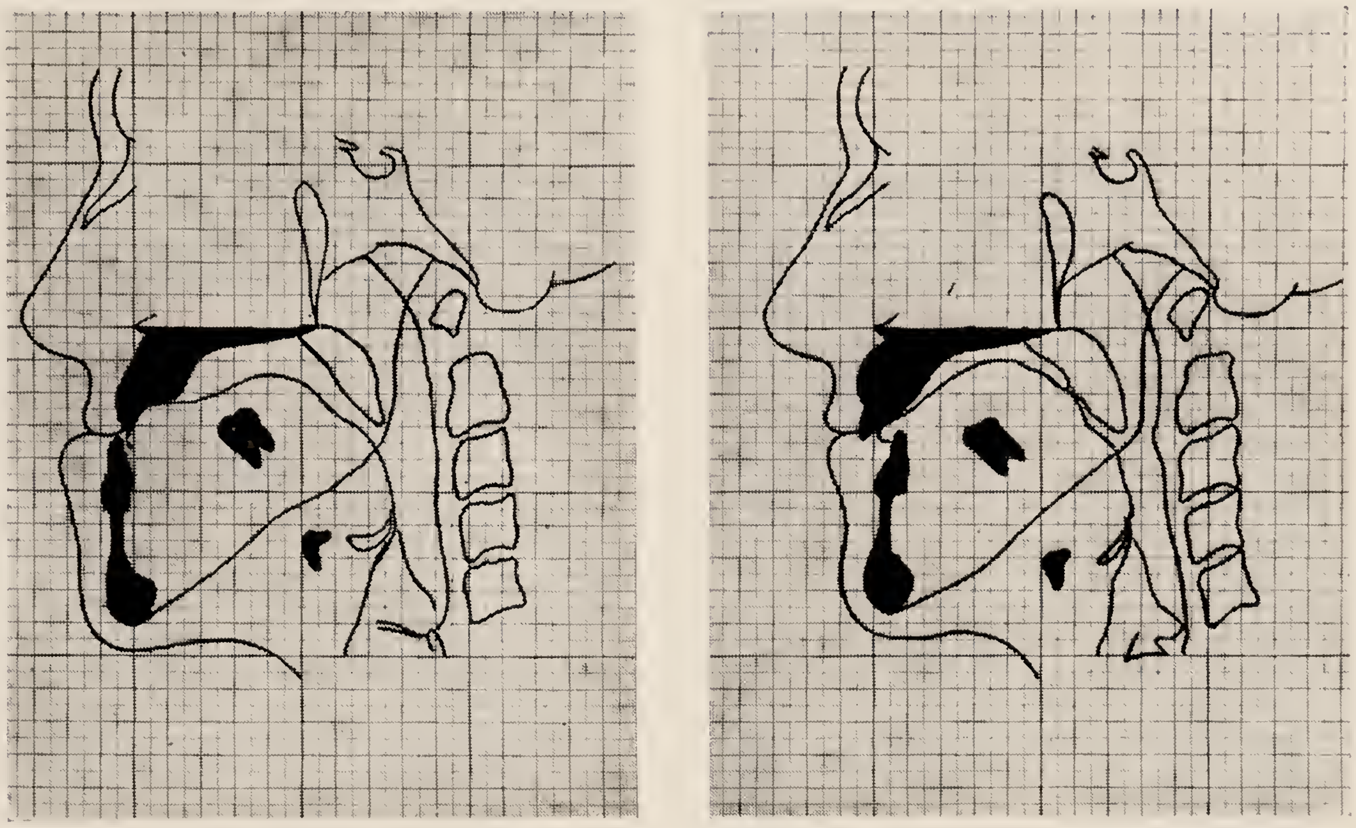
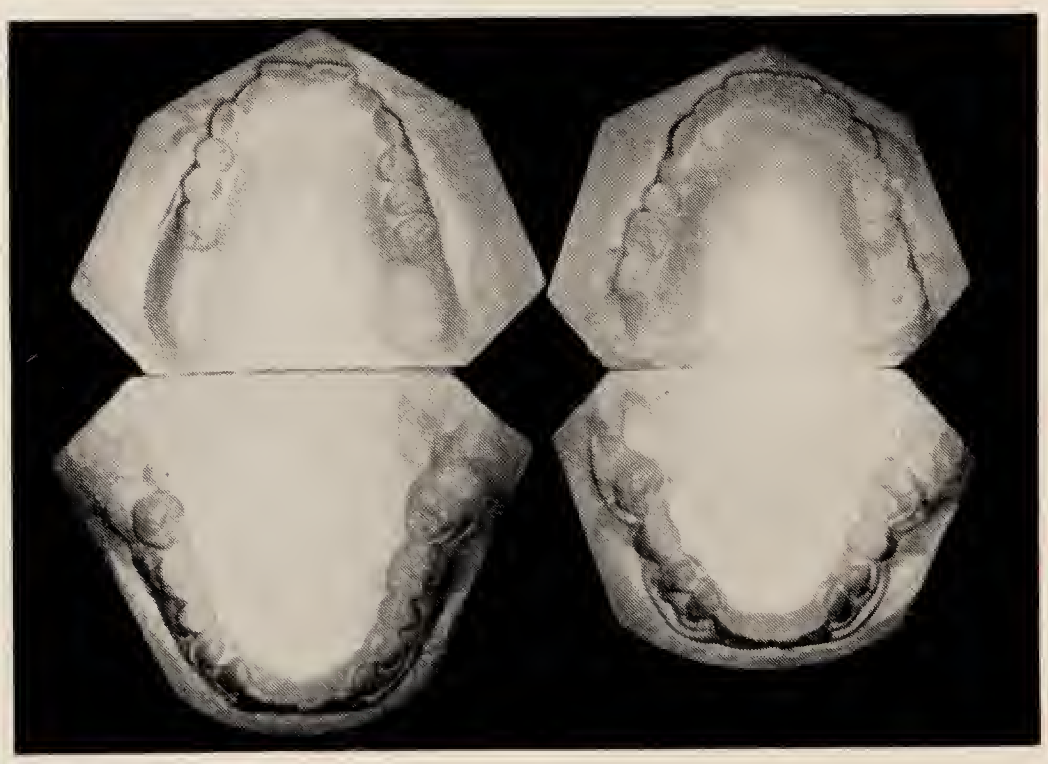


Fig. 2.—Pre- and postoperative cephalometric tracings of *Case* 1 on graph paper with 1 mm. squares enabling both quantitative and qualitative comparisons to be drawn.

A



B

Fig. 3.—A, Lateral view of models showing the occlusion pre- and postoperatively. B, Occlusal view showing the reduction in lower arch length and width as a result of surgery.

Secondly, the rigid dental and skeletal confines within which the movable organs must adapt to shape the vocal tract.

Thirdly, the tendency to do this with the optimal physiological economy, by structures whose primary function is not the production of the sounds of speech, but the continued maintenance of the respiratory airway and participation in swallowing.

For an experimental test of such a hypothesis, one would ideally like to have the situation where the variations of skeletal and other factors can be controlled and studied in isolation, whilst remaining features are kept constant. The best approach to such an ideal condition was thought

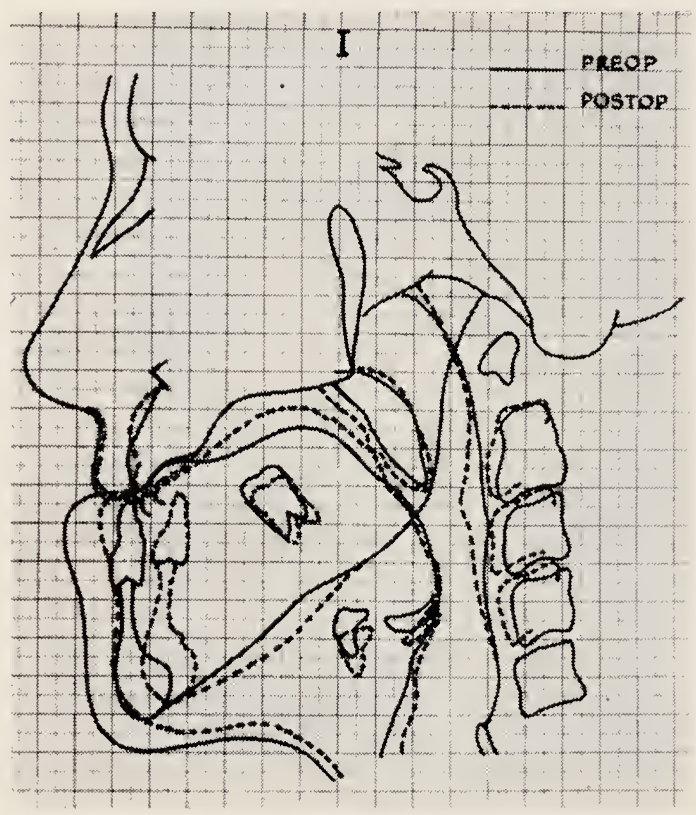


Fig. 4.—Cephalometric tracings superimposed on the maxillary plane at ANS. The dotted line showing the postoperative condition indicates both the extent of the reduction in intermaxillary space dimensions as well as the widespread adaptive adjustments in the oropharynx.

to be in patients who are undergoing surgical correction of skeletal abnormalities, such as severe mandibular prognathism. These patients were in all other respects normal.

Although the adaptive response in these cases is more rapid, and therefore dramatic, compared to the gradual change seen throughout the developmental period of children, or the modifications due to orthodontic treatment, it should be realized that in all three situations adaptation is initiated by the same underlying physiological requirements and achieved by means of similar neuromuscular mechanisms.

As with the normal series the pre- and post-surgical evaluations of these patients are based on cephalometric analysis, cineradiography, tape recordings of speech sounds, and study models.

Case 1

A.H., a 42-year-old single man, was referred by his dental practitioner to the prosthetics department (*Fig.* 1A). He was subsequently seen in oral surgery where $\frac{754|4567}{7521|1257}$ were extracted, and full upper and lower partial dentures provided.

On 25 February, 1965, he was admitted for surgical correction of his mandibular deformity by a bilateral body ostectomy.

Intermaxillary fixation from an upper Gunning splint with peralveolar wiring to a lower cap splint reinforced by circumferential wiring was used for three months. New dentures were provided a month later (*Fig.* 1B).

Observations and Comments on this Case

Reduction in the height and length of the intermaxillary space produced an increased amount of activity of all the structures concerned in the articulation of speech. There was a definite improvement in the clarity and general level of intelligibility of speech. Not only were the dental fricatives more differentiated, but the quality of vowels was also better.

As seen from tracings (*Fig.* 2) and the occlusal view of the models (*Fig.* 3) the reduction in the intermaxillary space was considerable in all three dimensions. This decrease in space produced adaptive postural changes which may also be observed on the cineradiographic film during respiratory pauses between the various sounds. The most striking response is shown by the tongue which postoperatively is more contracted antero-posteriorly and elongated vertically. The dorsum is more prominently humped above the occlusal plane, and the mode of posterior oral seal production is also noteworthy. This involves not only elevation of the dorsum, but a complete re-orientation of the tongue towards a more pharyngeal position (*Fig.* 4). This involuntary response is accompanied by a reflex depression of the hyoid and associated structures, presumably to accommodate the tongue in the reduced space without a reduction in the postlingual airway. The posterior seal is made by an apparently active ventral contraction of the soft palate with evidence of activity in the pharyngeal musculature. The appearance of the so-called Passavant's ridge can also be seen as a local prominence on the posterior pharyngeal wall shadow.

It is also important to note that the tip of the tongue shows very little change.

The surgical reduction in this patient's intermaxillary space has invoked reflex adaptations in speech movements which are in keeping with the normal series with comparable morphological determinants of intermaxillary space dimensions and may, therefore, be regarded as being predictable by extrapolation from the normal series.

Case 2

G.S., a 19-year-old Dutch girl (*Fig.* 5A), was referred by her dental practitioner with a gross anterior open bite extending distally as far as the second molars, which were the only teeth to contact in occlusion. The patient was concerned at showing her tongue when talking and laughing, and she also found it difficult to eat. She was unable to bite apples, etc. Her English was very good, but she had a pronounced anterior sigmatism.

Surgery was carried out in two stages. On 26 August, 1965, she was admitted for the surgical extraction of all four third molars, and at the same time a tongue reduction was performed. This was

according to the Obwegeser pattern, consisting of a V-shaped excision from the tip and an oval-shaped section from the dorsum, extending as far back as the circumvallete papillae in the midline. The cut surfaces were then approximated by sutures, which, in effect, resulted in a minimal reduction in length, but a considerable decrease in the width of the tongue.

Observations and Comments on this Case

Although there was a similar reduction in the intermaxillary space in this case (*Fig.* 7), the adaptive response on first viewing of the cineradiographic film appeared to invalidate the hypothesis. Instead of an increase in the amount

A

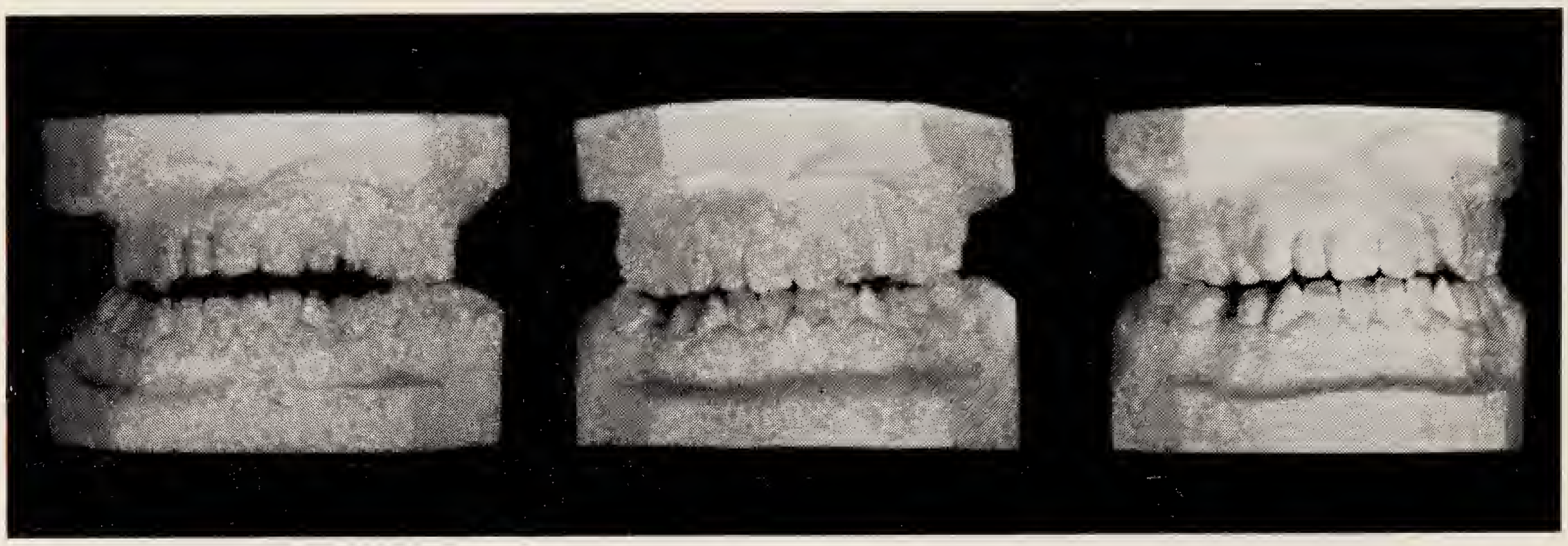
B

Fig. 5.—*Case* 2. A, Preoperative and, B, postoperative full-face and profile photographs.

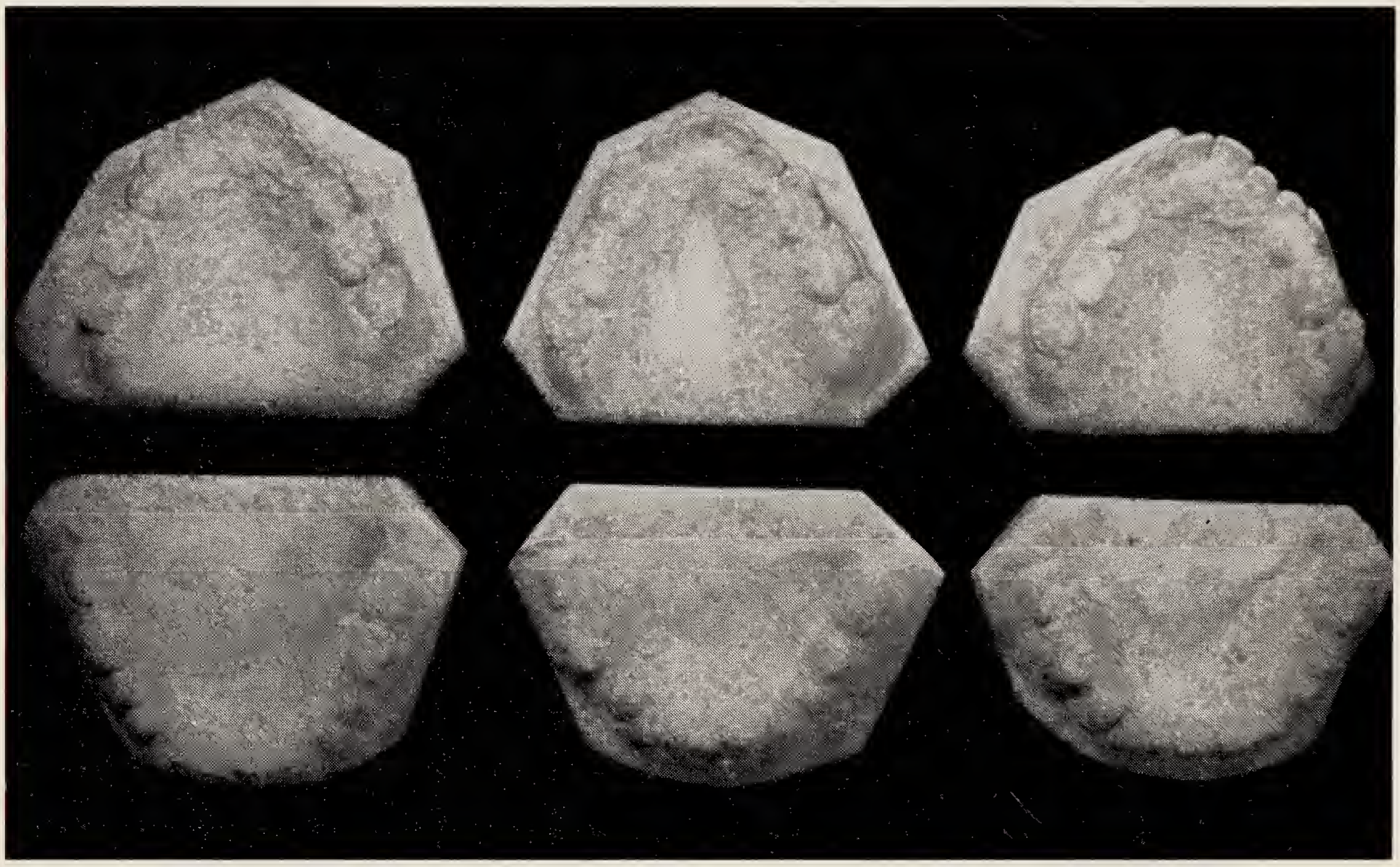
of overall activity as was expected, there was a definite decrease in the movements of the tongue, hyoid, and mandible.

On subsequent frame-by-frame analysis and examination of tracings made from selected

On 11 November, 1965, the patient was readmitted for the second stage. Following removal of $\overline{5|6}$ a bilateral body ostectomy was performed by an intra-oral approach. Fixation by cap splints and intermaxillary elastics was maintained for nine weeks (*Figs.* 5B, 6).



A



B

C

Fig. 6.—A, Anterior view of models: *left*, preoperative; *middle*, six months postoperative; *right*, twelve months after surgery. There is a slight reduction in overbite over the last six months. B, Occlusal aspect of the same models. C, Lateral view.

frames, it was noticed that a very considerable increase in lip movements was typical of all sequences (*Fig.* 8). However, this paradoxical (and initially disappointing) change in behaviour can nevertheless be accommodated by the hypothesis if a reasonable explanation exists for the obvious difference between these two patients' adaptive potentials.

Analysis of the cephalometric and cineradiographic records of *Case* 2 indicated that the postlingual airway in this patient is fairly narrow. In the absence of quantitative criteria for a normal range, this must, of course, remain a statement of clinical impression which is only based on the study of about sixty other cineradiographic records and a much larger number of cephalometric films. This special feature of a narrow postlingual airway, both before and after the surgical reduction of the tongue prior to the ostectomy, may account for the very limited adaptive potential of the hyoid and laryngeal structures. Since the tongue is automatically confined by the mandible as well as by the functional restrictions imposed through its laryngeal associations, it becomes reasonable to expect that for the readaptation for speech necessitated by surgical alterations, the lips and pharynx, as the structures with the least rigid ant properties of the vocal tract are maintained despite the reduction through ostectomy, and the vowels may be rendered practically unaltered despite the radically changed environment of the organs of speech.

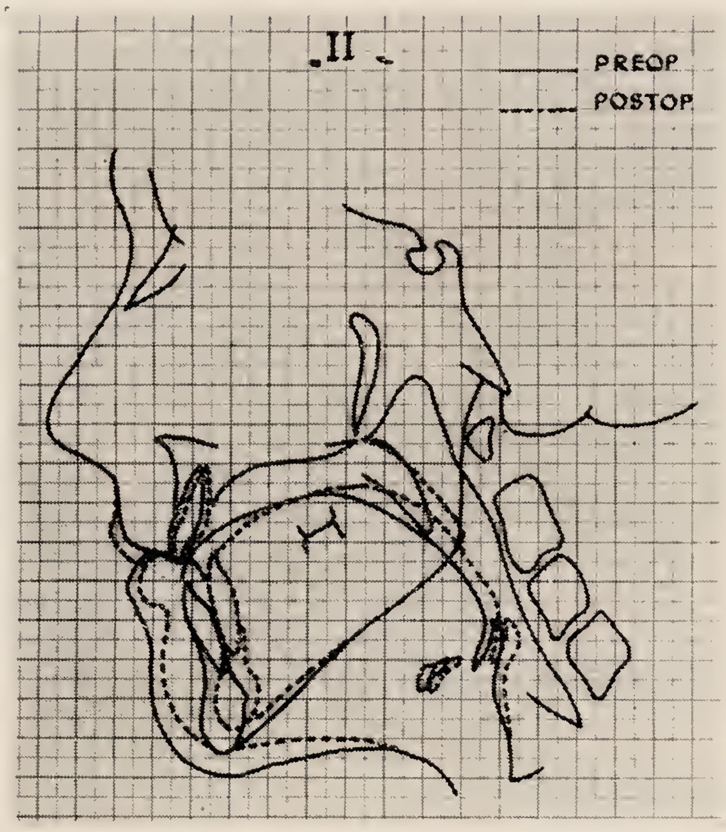


Fig. 7.—Superimposed cephalometric tracings: preoperative and six months postoperative.

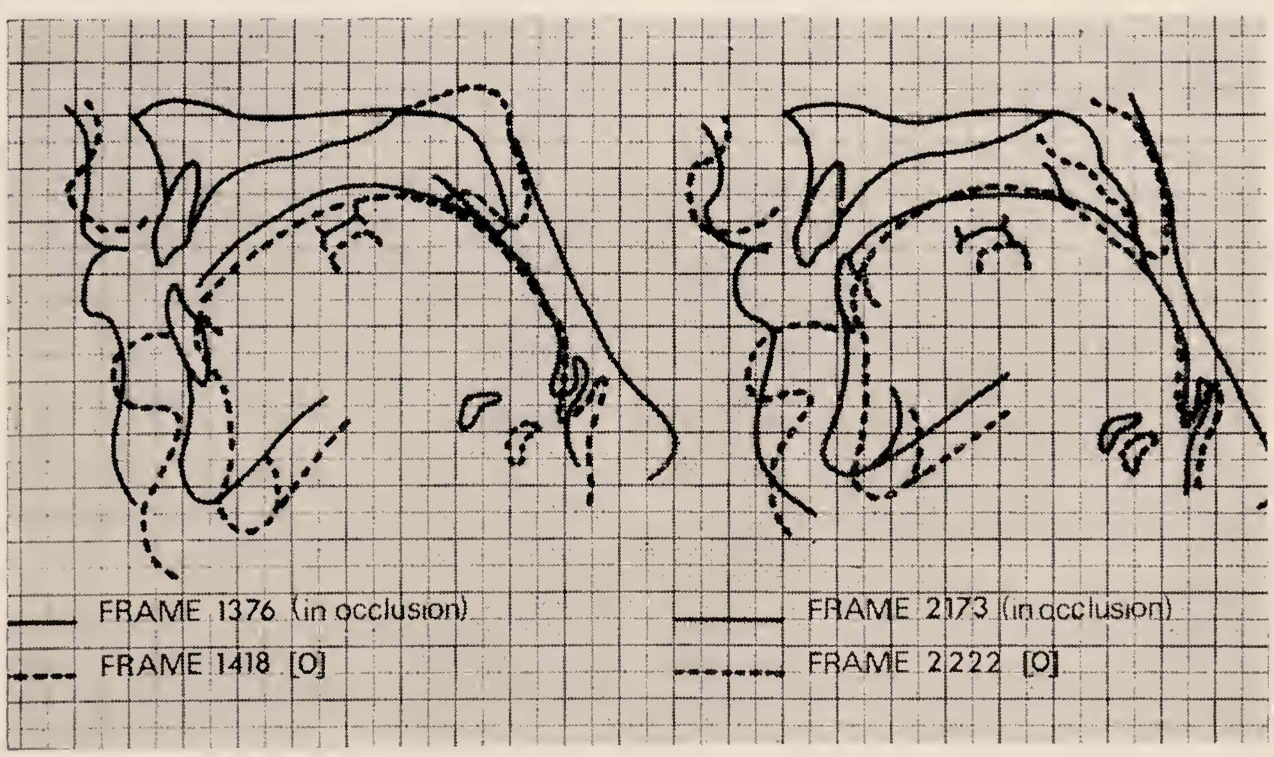


Fig. 8.—Tracings made from cephalometrically orientated cineradiographic films which were taken at 64 f.p.s. Superimpositions show the altered articulatory behaviour for the vowel O after surgery.

restrictions, should assume a major part in compensation.

The increased lip activity postoperatively is particularly striking in the production of the vowel O for which there is a considerable protrusion and rounding of the lips. The sound produced, however, is subjectively unchanged from the preoperative condition. This is a good example of the use of the lips to increase the effective length of the vocal tract. By this compensatory lip protrusion, the effective reson-

The other important change in speech postoperatively was the substitution of a lateral sigmatism for the anterior sigmatism. This may be attributed to the lingual narrowing due to the Obwegeser pattern of the partial glossectomy. The tongue was rendered inadequate to meet the conflicting demands for a lateral seal which is essential to block the space between the cheek teeth, and at the same time maintaining a midline groove, by bilateral contraction on its dorsal aspect, to provide the necessary collimation of an

air-stream, capable of generating sufficient acoustic energy for audible fricative sounds.

[Pre- and postoperative cineradiographs were shown and tape recordings of the speech sounds filmed were heard at this stage.]

Thus we may summarise and contrast the adaptive response in these two cases:—

Case 1: A decrease in space results in increased adaptive movements for speech. Thus increased activity compensates for the diminished freedom of movement.

Case 2: The relatively narrow postlingual airway seems to be the governing factor. Tongue reduction failed to overcome this limiting influence imposed on laryngeal and hyoid adaptability. Space reduction by ostectomy further reduced the freedom of tongue. However, the postoperative decrease in anterior lower face height renders the lips more than ' competent ', and, being endowed with a greater degree of physiological redundancy, are now used to maintain the total length of the vocal tract at its preoperative value.

CONCLUSIONS

This project is still in progress and several morphological factors besides intermaxillary dimensions remain to be evaluated for their possible significance in terms of function. Therefore, the following conclusions should be regarded as tentative, being offered not with a view to replacing any concepts which at this stage they may contradict, but merely to promote the practical acceptance of a more integrated functional view of the oro-pharyngeal complex.

1. The previously proposed relationship of the size and shape of the intermaxillary space and the type of soft-tissue behaviour may be a reasonable working hypothesis from which clinical criteria for individual comparisons and predictions on the adaptive response to changes may be derived.

2. It is therefore recommended that this is included in diagnosis as an index of the rigid environment of the soft tissues. In this study this was done by taking various height and length measurements of the intermaxillary space at its minimum, i.e., with the teeth in occlusion. This forms a readily grasped spatial concept within which the functional aspects of the mobile structures can be visualized. Both quantitative and qualitative analyses of function can thus be related to the morphology of the region. Such a fluid concept of the nature of the linguofacial balance may also enable us to recognize the clinical significance of the differential growth rates of the hard and soft tissues. The relative increase of tongue space following the continuing mandibular growth, which is said to occur subsequent to the cessation of tongue growth and its later descent, must influence the muscular equilibrium of the dentition in differing ways according to the particular point reached in the patient's development. This may well prove relevant to the timing of orthodontic treatment.

The addition of this type of analysis to the routine orthodontic assessment has several potential advantages. The two-dimensional nature of cephalometric evaluations in current use may usefully be extended from merely dealing with linear concepts to an appreciation of spatial relationships. Although this does not entirely compensate for the lack of a third dimension it is a significant improvement in the realistic interpretation of cephalometric data.

Whilst it is appreciated that an excessive number of landmarks and indices is undesirable, the danger of oversimplification by taking too limited estimations lies in completely invalidating the entire procedure. (For example, it may be useful to eliminate two linear values by their angular relationships, but in doing so it is to be remembered that precise information in two planes has been reduced to a generalization in a single plane.)

3. From the preceding case reports it is seen that clinically minor or even imperceptible postural changes by the tip of the tongue may in fact be accompanied by grossly modified compensatory behaviour in the larynx, pharynx, and the remaining 90 per cent of the tongue which normally eludes clinical scrutiny.

Lips, by contrast to the tongue, appear to assume substantially altered positions without the same degree of generalized postural modifications in remoter structures.

This observation seems to imply that the lips, especially if morphologically adequate, are more adaptable than the tongue.

4. Regarding the planning of surgery for mandibular deformity, there are several guides which could be useful in evaluation of the best approach for a stable result with optimum function.

a. In selecting the site for reduction of a prognathism it should be borne in mind that the nearer to the front of the intermaxillary space that the length is lost, the less is the space loss in the horizontal plane. This, of course, is a critical factor for stability as it involves arch form reduction concurrently with radical loss of intermaxillary space.

b. Although tongue reduction is not thought to be indicated in the majority of surgical Class III cases, it is nevertheless useful to obtain an estimate of the tongue size and freedom of movement in relation to its preoperative intermaxillary environment. Apart from the obvious need for such assessment as the basic issue in prescribing tongue reduction, it must likewise be a critical factor in deciding the extent of correction which provides the best compromise

between cosmetic improvement without subsequent functional impairment.

If, on cineradiographic examination (or perhaps even from a few cephalometrically orientated lateral skull films), it is seen that during speech, respiration, etc., the range of positions assumed by the hyoid is quite extensive both in the vertical and horizontal, it may be an indication of a greater degree of freedom of lingual adaptability. In such cases, even though the tongue may be in close proximity to the labial segments both at rest and in function, it should not be regarded as a ' large tongue ' requiring surgical reduction.

If, however, the hyoid and the root of the tongue show a very narrow range of activity with movement predominantly in the vertical plane (and especially if the posterior pharyngeal wall shadow tends to be thickened, in the region of Passavant's ridge, when there is evident muscular effort in the soft palate as it contacts the tongue during the production of a posterior oral seal), then care should be taken to avoid further cramping of a tongue whose range of movement is already fairly restricted.

c. The extent of lip activity in speech may also suggest the degree of adaptive potential of the tongue and associated structures within the intermaxillary space. In particular, if the patient is observed during the phonation of sustained O and EE sounds, the range of positions from maximum protrusion and rounding of lips to maximum retraction and spreading may be seen. Little movement indicates adequate space in the vocal tract for adaptation without significant recourse to labial assistance. Most cases (and also non-surgical subjects), having only limited space for the tongue, demonstrate fairly active lip behaviour in speech.

Finally, it seems clear that the procedure for investigating the normal group and as applied to these surgically treated cases can shed further light on interactions of the various components within the region. Such information seems potentially useful not only for those concerned with speech, but also for contributing to more accurate clinical assessment of orthodontic and surgical cases.

Acknowledgements

I wish to express my thanks to Professor H. C. Killey and Mr. N. Rowe for allowing me access to these and other surgical cases, and for permission to publish their results. I am also indebted to Dr. J. Prior, our consultant radiologist, for his help with cineradiography for the past three years.

My sincere thanks are due to Professor C. F. Ballard for supporting, and, indeed, enabling this investigation to be carried out.

Finally it must be recorded that without the generous support of the Medical Research Council and the Central Research Fund of the University of London this project would not have been possible.

REFERENCES

Ballard, C. F. (1955), *Dent. Practit.*, **6**, 3.

— — (1957), *Ibid.*, **8**, 2.

— — and Bond, E. K. (1960), *Speech Path. Ther.*, **3**, 55.

Vig, P. (1965), *Dent. Practit.*, **16**, 75.

DISCUSSION

Professor W. J. Tulley said that on seeing a film of this kind it is important to realize the considerable work which goes into the tracing of individual frames and their analysis.

With such modern aids as the image intensifier one could study tongue movements two-dimensionally, but it did not enable one to make a study of the lateral changes.

Mr. Vig had said that in the case of the girl's speech it had changed from an anterior to a lateral sigmatism. He asked Mr. Vig if he thought the girl's occlusion was now stable and asked what was the interval between the two sets of models. Apart from the action of the tongue there was always the question of the pull of other muscles disturbed by the surgical treatment. Did Mr. Vig think that in two or three years' time she might well develop an open bite again?

Mr. P. Vig said that, regarding stability of the occlusion, he hoped to follow this girl up: she had promised she would come back in six months' time. He did not think she would have a complete overbite in two or three years. Regarding stability of speech, that could also change. He thought she would continue to experience difficulty with certain speech sounds because now that the tongue was narrower, but more or less the same length, there were two conflicting functions it had to perform. It had to perform the function of producing grooving in the dorsum to produce the jet of air for certain inflective sounds. It had to seal off the interocclusal clearance when she opened her mouth to speak. She might well change: it was only four weeks after ostectomy. She had said she thought her mouth was too small, but she thought her speech was much better, although at first Mr. Vig said he could not understand what she said. Then he had asked her why did she think her speech was better, and she said no-one could see her tongue any more, and this was some measure of the success of the treatment.

Mr. A. C. Campbell said he was interested from the clinical point of view. Such a problem as the last one had come his way, as it must have come the way of all of them from time to time—these were tremendous problems. In his case, consideration of some lingual surgery had had to be made. He wondered whether, in relation to this particular case, Mr. Vig felt there were any satisfactory methods, pre- and postoperatively, of making assessments of tongue function—apart from speech sounds as he had demonstrated—and whether there were any things

one could measure quantitively, because subjective observation was not enough.

He had noted a query about the patient's subjective feeling. Mr. Vig had said the girl felt her mouth was too small, and her speech better. Had she felt it was something she disapproved of, or did she feel changed in any other way, or was this reaction only the immediately postoperative one?

Mr. Vig, taking the second question first, said the girl felt generally much happier, because she now took far greater pains to look attractive, and was not ashamed to speak in public as she used to be. These comments had been made some time after the surgery: she had had one appliance off, and came back two weeks later to have the other one off, and had had time to get used to it and to assess the tongue in use. The only way to assess changes was by having a set of normals. His own normal series was only 28, although it represented a great variation of intermaxillary space and tongue operation. This was the only way to establish criteria for assessing tongue behaviour before, and estimating adaptations afterwards. He hoped by doing more of this work eventually to relate certain reduction in the dimensions of intermaxillary space to certain adaptations occurring afterwards, but it was only the beginning of the whole study.

Mr. P. M. Benzies had two technical points to raise. Firstly, comparing the two films, the first, the man, showed a reasonable amount of movement of the hyoid and tongue to begin with. Mr. Benzies said he did not follow whether the man had had less movement in speech and swallowing after the operation. Secondly, he had been interested to see that the girl had very much more movement of tongue than before operation. He had put that down to the fact that the hyoid movement was lower in the pharynx. A third point concerned what was the specific pattern of behaviour in a Class II, division 2 type ?

Mr. Vig said the first case had shown an overall increase in movement following ostectomy.

In the girl, after surgery, there was an overall decrease in hyoid movement, although all the activity took place at a lower level. He had taken this to mean she had had to depress the hyoid to allow sufficient space for the tongue to operate in the skeletal confines.

As to type of movement, in Class II, division 2 types these patients usually showed a type of short, low, and relatively backward position of intermaxillary space.

Class II types showed the greatest amount of movement of the mandible, and all other structures such as tongue and hyoid moved tremendously up and down. The lips accompanied the movement of the mandible, but the general vertical disposition of the structures was far from variable in the Class II, division 2 types where there was a shortness and shallowness of the intermaxillary space.

Mr. D. J. Timms asked Mr. Vig to enlarge on the neuro-physiological implications of this work, and the adaptive aspects.

Mr. Vig said the implications were many and widespread, because of certain questions of fundamental concepts behind what they believed to be the current orthodontic rationale. He would prefer to leave this to a future occasion.

Mr. H. Lester asked Mr. Vig if he knew what was the clinical justification for the glossectomy having been carried out in that particular region of the tongue. Was there any temporary impairment in the sensation or function of the tongue after the glossectomy was carried out?

Mr. Vig said he had asked the same question of the surgeon who had done it. He had been told it was too big.

REPORTS OF MEETINGS

ORDINARY MEETING, 10 January

An Ordinary Meeting of the Society was held at Manson House, 26, Portland Place, London, W.1, on Monday, 10 January, 1966, at 6.30 p.m., with the President, Mr. R. E. Rix, in the Chair.

Apologies for Absence

Apologies for absence were received from Mr. W. H. Nicholl and Mr. J. M. McKinnon.

Minutes

The Secretary (Mr. A. C. Campbell) read the minutes of the Ordinary Meeting held on 13 December, 1965. These were confirmed and signed by the President.

Candidates for Election

The following were elected to Ordinary Membership *en bloc* by show of hands:—

Mr. C. J. Delaney, B.D.S. (U. Glasg.), 26, Parklee Drive, Carmunnock, Glasgow.

Wing Cdr. J. S. Johnson, M.Sc. (U. Lond.), F.D.S. R.C.S. (Edin.), D.Orth. R.C.S. (Eng.), 14, Mansion Hill, Halton, Aylesbury, Bucks.

Mr. P. E. Lewis, B.D.S. (U. Sydney), D.Orth. R.C.S. (Eng.), 104, Queen's Road, London, S.E.15.

Mr. S. L. Potokar, B.D.S. (U. Brist.), 23, Bramble Drive, Sneyd Park, Bristol 9.

Mr. H. B. Valentine, B.D.S. (New Zealand), 16, Queen's Gardens, Heston, Middlesex.

The President, on behalf of the Society, welcomed any visitors who might be present and hoped they would take part in any discussion which would follow his paper. Although it was nominally the Presidential Address, he hoped there would be time for questions to be asked. He then delivered his Presidential Address entitled, '*Further Thoughts on Monobloc Therapy*'.

Following the discussion of the Presidential Address a vote of thanks to the President was proposed by Professor C. F. Ballard and carried with acclamation.

The President thanked Professor Ballard for the kind things he had said.

He announced that the next meeting was to take place on Monday, 14 February, 1966, at 6.30, when Dr. Mills would read a paper entitled '*An Assessment of Class III Malocclusion*'.

He then declared the meeting closed.

ORDINARY MEETING, 14 March

A Meeting of the Society was held at Manson House, 26, Portland Place, London, W.1, on Monday, 14 March, 1966, at 6.30 p.m., with Mr. R. E. Rix, the President, in the Chair.

The President said it was his sad duty to report the death of Mr. H. T. A. McKeag, *C.B.E.* Mr. McKeag had been a member of the Society since 1920, he had been its President in 1950, and President of the E.O.S. in 1959. He had made considerable contributions to the study of orthodontics, and he had received the honour of *C.B.E.* for his contributions to dentistry and dental education in Northern Ireland. All who knew him were struck by his modesty and kindliness.

The meeting stood for a few moments in respect to his memory.

Apologies for Absence

Apologies for absence had been received from Dr. O'Meyer, Miss Ritchie, Mr. Rose, Mr. Scott Page, Miss B. Taylor, and Mr. Wilkie.

Minutes

The Minutes of the previous meeting held on 10 January, 1966, were read by the Secretary, confirmed, and signed as a correct record.

Mr. H. B. Valentine, whose election had been confirmed at a previous meeting, was introduced to the President.

Candidates for Election

The following candidates were elected:—

Ordinary Membership

Mr. D. B. Johnson, B.D.S. (Dunelm), F.D.S., D.Orth. R.C.S. (Eng.), 23, Woodvale Gardens, Wylam, Northumberland.

Major M. J. Newell, R.A.D.C., B.Ch.D. (U. Leeds), F.D.S., D.Orth. R.C.S. (Eng.), c/o Westminster Bank Ltd., Park Row, Leeds 1, Yorks.

Mr. P. J. O'Connor, B.D.S. (N.U. Irel.), D.Orth. R.C.S. (Eng.), 1, Sydney Place, Cork, Ireland.

Mr. P. G. Sullivan, L.D.S. R.C.S. (Eng.), 80, Wickham Road, Highams Park, London, E.4.

Mr. A. K. Tipnis, B.D.S. (Bombay), F.D.S., D.Orth. R.C.S. (Eng.), Royal Portsmouth Hospital, Portsmouth, Hants.

Corresponding Membership

Dr. Sam Blausten, D.D.S. (N.Y.), 253, Main Street, Farmingdale, New York, U.S.A.

Dr. Nathan J. Sachs, D.D.S., 84-75 168th Street, Jamaica 11432, New York, U.S.A.

The PRESIDENT welcomed any visitors who might be present, and hoped they would consider themselves members for the evening and at liberty to take part in any discussions following the papers.

He then introduced Mr. C. P. Briggs, who presented a short paper entitled, '*Some Indications for the Use of Fixed Multibanded Appliances*'; after which Mr. P. Vig presented his short paper entitled, '*Adaptation to Altered Morphology—Illustrated by Two Surgical Cases*'.

ORDINARY MEETING, 18 April

An ORDINARY MEETING of the Society was held at Manson House, 26, Portland Place, London, W.1, on Monday, 18 April, 1966, at 6.30 p.m., with Mr. R. E. Rix, the President in the Chair.

Apologies for Absence

Apologies for Absence were received from Mr. McEwen, Mr. Nicol, and Mr. Robertson Ritchie.

Minutes

The SECRETARY, (Mr. A. C. Campbell) read the Minutes of the meeting held on 14 March, 1966, and they were confirmed and signed as a correct record.

The following members were introduced to the President: Mr. A. K. Tipnis; Mr. P. G. Sullivan.

Candidates for Election

The following candidates were elected to Ordinary Membership.

Mr. F. L. Coker, L.D.S. R.C.S. (Eng.), Keay House, Town Square, Basildon, Essex.

Mr. A. A. M. McDonald, L.D.S., D.Orth. R.C.S. (Eng.), 5, Baillies-wells Terrace, Bieldside, Aberdeen.

The PRESIDENT welcomed any visitors who might be present and assured them that they were free to take part in any discussion that might arise after Dr. J. R. E. Mills' paper.

He then called on Dr. Mills to present his paper entitled, '*An Assessment of Class III Malocclusion*'.

RESEARCH MEETING, 19 May

THE RESEARCH MEETING of the Society was held in the Pavilion, Eastbourne, on Thursday, 19 May, 1966. The President, Mr. R. E. Rix, occupied the Chair and papers and research reports were presented as follows:—

Mr. R. A. Latham and Dr. W. R. Burston: '*The Postnatal Pattern of Growth at the Sutures of the Human Skull*'.

Mr. C. C. Knowles: '*Cephalometric Treatment Planning and Analysis of Maxillary Growth following Bone Grafting to the Ramus in Hemifacial Microsomia*'.

Mr. C. P. Adams: '*Relationship between Facial Growth and Incisor Overbite*'.

Mr. R. Fawcus: '*An Investigation into Lingual Sensory Motor Skills in Children and Adults with Normal Speech*'.

ANNUAL GENERAL MEETING, 20 May

THE ANNUAL GENERAL MEETING of the Society was held in the Pavilion, Eastbourne, on Friday, 20 May, 1966, at 9 a.m., with the President, Mr. R. E. Rix, in the Chair.

Minutes

The Minutes of the Annual General Meeting held on 13 December, 1965, were read, confirmed, and signed as a correct record.

Election of Officers and Councillors

The PRESIDENT said that there had been nominations by the retiring Council together with two nominations for Councillors from members. He suggested that the question of Council nominations be left for the moment and asked whether the Council nominations to offices other than that of Councillor were accepted.

These were accepted as follows:—

President:	Mr. J. D. Hooper
Immediate Past President:	Mr. R. E. Rix
President Elect:	Mr. J. S. Beresford
Senior Vice-President:	Prof. D. P. Walther
Vice-President:	Mr. T. Jason Wood
Treasurer:	Mr. J. S. Rose
Secretary:	Mr. Alan C. Campbell
Assistant Secretary:	Mr. C. P. Briggs
Editor:	Dr. J. R. E. Mills
Curator:	Mr. B. C. Leighton
Librarian:	Miss J. G. Ritchie

The PRESIDENT said that there were vacancies for five Councillors. The Council's nominations were: Dr. W. Grossmann, Mr. M. A. Kettle, Mr. W. A. Nicol, Mr. N. R. E. Robertson. They were all entitled to hold and traditionally held office for three years; none of them had yet served that time. In addition there were nominations for Mr. T. D. Foster and Mr. J. R. Pettman. The best way of deciding these Councillors would be by a paper ballot, and the Secretary had facilities for this.

Mr. Walpole Day said that it had always been the custom of the Society to allow Council members once elected to serve their full time of three years—in this particular instance, it would be only two-and-a-half years. He wondered whether the feeling of the meeting should be tested as to whether members should, by show

of hands, indicate whether they would like to continue the custom by electing the four Councillors who were already members of the Council, so that they should continue in office for the next year. He proposed that a show of hands should be taken.

Mr. J. S. Beresford seconded the motion which was put to the meeting and carried.

On a show of hands the four members nominated by Council were elected.

There being one further vacancy to be filled, members agreed on a show of hands to decide this.

The PRESIDENT declared that Mr. T. D. Foster was elected by 46 votes to 14 to fill the vacancy on the Council.

On the motion of Mr. Rose, seconded by Mr. Walpole Day, Mr. P. H. Burke and Mr. J. F. Pilbeam were re-elected auditors.

Treasurer's Report

The TREASURER (MR. J. S. ROSE) said that under the new Constitution, the financial year of the Society now ran from 1 January to 31 December. In contradistinction to the rest of the Society's arrangements, the financial year during the changeover period lasted for fifteen months, and the Society was in the eighth month of that year. He could therefore offer what might be termed an interim report, and there was no published statement of audited accounts.

On 16 May, 1966, the current account of the Society had a balance of £714 19s. 9d., and there was £1500 in the deposit account.

In his report to members at the last Annual General Meeting, he had mentioned that the Council were reviewing the Society's investments. With the help of advice from the Westminster Bank Brokers, the Society's holdings of 1959/69 Funding Stock, 5 per cent Defence Bonds and City of London Real Property Stock has been sold. Together with the money from the Hertfordshire County Council Stock which had matured last December, the Society had bought Convertible Loan Stock of the following companies:—

Boulton & Paul Ltd.
Sun Alliance London Insurance.
Fison's Ltd.
Baker Perkins Holding Ltd.

These should increase the Society's income.

He moved the reception of the report.

The report was adopted.

Secretary's Report

The SECRETARY (MR. A. C. CAMPBELL) said that the year had been one which was out of the ordinary in the history of the Society for a variety of reasons. The President occupied the Chair for the second time; it had been a short meetings year; the Annual General Meeting was held for the first time in May at the Country Meeting, and a meeting had had to be cancelled because of the threatened rail strike. Also, meetings had been held at 6.30 p.m. instead of 7.30.

Meetings had been well attended with an average attendance of 100, which was, in fact, higher than the attendance at the corresponding three meetings in the first part of the year, in past years. This was certainly high bearing in mind that the Country Meeting figures had not been included to boost the average.

During the year, the Society had lost an Honorary Member in the death of Mr. H. T. A. McKeag and one ordinary member by resignation owing to ill health.

With the elections at the Country Meeting, the membership would comprise 515 Ordinary Members and 73 Corresponding Members, making a total of 588; 17 new members had joined the Society—14 Ordinary and 3 Corresponding.

He moved the reception of the report.

The report was adopted.

Editor's Report

The EDITOR (DR. J. R. E. MILLS) said that there had been no change in editorial practice during the short period covered by the report. Publication of the 1965 TRANSACTIONS in the *Dental Practitioner* would be completed in the May issue and the bound volume of TRANSACTIONS should be in members' hands within the next few months.

Although the session which ended with the Country Meeting was a short one, it would contain almost a full complement of papers and the Council had therefore decided that the TRANSACTIONS for this period would be published as a complete volume which would be despatched to members in due course.

He moved the reception of the report.

The report was adopted.

Curator's Report

The CURATOR (MR. B. C. LEIGHTON) said that for some time doubts had been entertained about the value of a Museum which was little more than a repository for interesting material, particularly when it was rarely visited and was unknown to most members. In recent years, this neglect had been fostered by the uninviting environment in which the Museum was housed. It seemed, therefore, that steps should be taken firstly to alter the nature of the Museum by giving it a more positive appeal to members' interest, and secondly, to lay it by stages before the members. The Council had therefore agreed to the expenditure of up to £40 for the reproduction of study models, showing examples of normal occlusion, in acrylic resin. This work had been undertaken, and was arranged in one

of the display drawers which would be on view to members during the demonstrations. It was hoped that members would not hesitate to express comment on the display, and perhaps offer suggestions on ways of taking advantage of modern materials to make it more attractive and interesting. In addition to this, a few of the recent additions to the Museum were to be on view.

Finally, he reminded members that donations to the Museum would be most welcome. Particularly valuable were examples of appliances which were of historical interest, and longitudinal series of models depicting the development of normal occlusion.

He moved the reception of the report.

The report was adopted.

Librarian's Report

The LIBRARIAN (MISS J. G. RITCHIE) said that there was always a certain sameness between the reports of the Librarian and the Curator. Once again, members were reminded that the Library was housed at the Institute of Public Health where books, transactions, and journals could be borrowed. A new book list was being compiled and would be circulated to members. One great difficulty was the lack of accommodation for the Society's books. As a result it had been necessary to curtail the exchange, temporarily, of the Society's TRANSACTIONS with the official publications of other foreign Societies. Those curtailed at present were from Brazil and Spain. The sale of the Society's TRANSACTIONS to such Societies had been offered as an alternative.

She moved the reception of the report.

The report was adopted.

The PRESIDENT said that as a result of the earlier time of the meeting, which had been in operation for the last three meetings, there had been no falling off in attendance. In fact, there had been a slight increase. The Council had discussed the continuance of this practice and thought that anyway it would be worthwhile continuing with the present time for another twelve months. He asked if members agreed. (Agreed.)

Any Other Business

Mr. F. Allan said that there was a motion before the meeting which had been seconded.

The PRESIDENT said that a motion had been proposed by Mr. Allan, and seconded by Mr. H. Lester, 'That the Council of the British Society for the Study of Orthodontics be reconstituted so that one half of the members are drawn from the academic and hospital field and one half from orthodontists practising in the general services; that the President be elected from each of the two fields in alternate years'.

Mr. F. Allan spoke to his motion, and in the ensuing discussion, the following members took part: Messrs. E. J. R. Bird, H. Pogrel, J. S. Rose, H. Lester, and J. R. E. Mills.

The President thanked members for their observations and said the Council would bear them in mind in considering whether it should propose any change in the Constitution.

COUNTRY MEETING, 20 and 21 May

The Ninth Country Meeting of the Society was held at the Pavilion, Eastbourne, on 20 and 21 May, 1966.

The PRESIDENT, Mr. R. E. Rix, occupied the Chair.

Minutes

The minutes of the Ordinary Meeting held on 18 April, 1966, were read, confirmed, and signed by the President.

Candidates for Election

The following candidates were elected *en bloc* by show of hands:—

Ordinary Membership

Mr. F. R. Tata, B.D.S. (U. Bombay), F.D.S., D.Orth. R.C.S. (Eng.), 10, Sylvester Avenue, Chislehurst, Kent.

Mrs. S. Roberts, B.D.S. (U. Lond.), L.D.S. R.C.S. (Eng.), 36, Merrow Chase, Leylsdene, Merrow, Guildford, Surrey.

Corresponding Membership

Mr. M. F. Tam, B.D.Sc. (U. Queensland), D.D.O. (R.C.S. Glasgow), D.Orth. R.C.S. (Eng.), c/o 49, Kensington Hall Gardens, Beaumont Avenue, London, W.14.

The Programme of the Meeting was then presented as follows:—

9.30 a.m. 20th Northcroft Memorial Lecture: Professor B. M. Foss: '*Some Psychological Techniques for Controlling Movements*'.

11.00 a.m. Coffee.

11.15 a.m. Paper: Mr. J. S. Rose: '*A Survey of Congenitally Missing Teeth, Excluding Third Molars, in* 6000 *Orthodontic Patients*'.

12.00 noon. Short paper: Mr. H. S. Orton: '*Some Cases Showing the Deliberate Labial Movement of the Upper Incisor Apices during the Reduction of the Overjet*'.

12.30 p.m. Luncheon.

2.30 p.m. Table Demonstrations: Dr. W. Russell Logan: '*The Vestibular Appliance*'. Mr. E. K. Breakspear: '*Indications for Extraction of the Lower Second Permanent Molar*'. Mr. J. D. McEwen and Mr. J. H. Martin: '*The Rapid Assessment of Cephalometric Radiographs*'. Mr. R. W. Willcocks: '*Some Cases treated with Extraction of Second Molars*'. Mr. D. Seel: '*A Rationalization of some Orthodontic Clasping Problems*'. Mr. D. DiBiase: '*The Treatment of Cases Involving Buccally Placed Canines*'.

The following demonstrations were open for inspection throughout the Meeting: Mr. B. C. Leighton: '*Some Cases of Normal Occlusion presented to the B.S.S.O. Museum*'. Mr. C. P. Adams and Mr. W. A. B. Brown: '*The Adams Cephalostat*'. Professor W. J. Tulley and Mr. A. C. Campbell: '*The Use and Abuse of the Monobloc*'.

3.30 p.m. Tea.

7.00 p.m. Reception by Councillor Mrs. K. J. Underhay, J.P., Mayor of Eastbourne, in the Winter Garden Cafe.

8.00 p.m. Society Annual Dinner in the Congress Restaurant.

Saturday, 21 *May*

9.30 a.m. Symposium: '*Aspects of the Dental Development of the Child*'. Dr. L. M. Clinch: '*The Development of the Deciduous and Mixed Dentitions*'. Mr. B. C. Leighton: '*The Early Development of Cross-bites*'. Dr. G. B. Winter: '*Local Pathological Conditions influencing the Development of the Upper Labial Segment*'.

11.00 a.m. Coffee.

11.15 a.m. Discussion on the Symposium.

Following the Symposium, the President said that it remained for him to retire gracefully from the platform. He had much enjoyed his second period of office. It was a great honour that members had asked him to come back again after twenty years. He was about to be replaced now by a young and vigorous, but experienced, practical orthodontist who would, he was sure, give members an interesting, stimulating year's programme.

The President then invested Mr. J. D. Hooper with the jewel of office.

Mr. Hooper said that he was deeply grateful for and appreciative of the great honour done to him in electing him President of the Society. He could quite honestly say that he had never dreamed that his name would come to be associated with the very eminent and respected men who had held this office in the past. His diffidence in accepting the office had not been reduced by having to follow a man like Mr. Rix who was held in the very highest degree of affection and regard by all his colleagues.

He would do his best to try and repay the trust of members by upholding the dignity of the office and promoting as best he could the interests of the Society.

Professor W. J. Tulley, on behalf of all present, proposed a very sincere vote of thanks to Mr. Rix. Mr. Hooper had already said the burden of what he had wanted to say, but he felt he had probably known Mr. Rix better than anyone present, as he had worked closely with him over the last twenty years. The second term of office was a great token of the affection that members had for him. He was a great teacher, a great clinician, and one of the things he had taught everyone was never to be too pessimistic. A wave of pessimism had spread through the Society a few years ago, but if members had seen the work Mr. Rix did, they would realise that there was a certain magic quality about his orthodontics. He was a great observer, one who had taught members more about timing orthodontic treatment than anyone he knew. His gentle manner and great sincerity had endeared him to all.

The President then closed the proceedings with the announcement that the next meeting would be held at Manson House on Monday, 10 October, at 6.30 p.m., when he would deliver his Presidential Address.

SUBJECT INDEX

AUTHOR INDEX